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Special Conservation Issue

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ROTUNDA

the magazine of The Royal Ontario Museum

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Bronze and Bronze Disease

Cover: The Virgin Mary attributed to Louis Jobin (1845–1928). This eight-foot painted pine figure from Quebec arrived in fragmentary condition—the picture shows the head before conservation treatment. The statue is now on display in the Quebec Gallery of the Canadiana Department.

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On Conservation

ANYONE WHO WANTED to epitomize in half-a-dozen words the main preoccupations of industrial civilization in this second half of the 20th century could hardly avoid including "conservation" somewhere in the list. The demands that an industrialized society makes upon its environment—demands imposed by ever-increasing millions with ever-rising expectations—have brought it home to our own generation as to none other before it that the resources of our planet that once seemed endless and inexhaustible do have an end—an end that in some cases already seems uncomfortably close. Suddenly we are aware that the seas and the rivers and the lakes, the forests, the fields, and the fauna, the oil and the minerals, and indeed the very air we breathe must all be conserved if they are not to be despoiled and squandered to the point where human life itself is imperilled.

But though our wasting natural resources may provide the most dramatic reminders of the need for conservation, they are not the only priceless assets of the human race that are in peril. The material legacy of the millennia of human culture is in many ways even more fragile and is endangered not only by human depredations but by the very processes of time and nature themselves. In this field the forces to be contended with are in a large measure perennial and not peculiar to our own times. The scientific/industrial age, to be sure, has brought some threats unknown to earlier ages—the corrosive pollutants in our atmosphere, for example, and the vibratory shock of modern road and air traffic, both of which may spell doom for structures that have withstood the centuries. Against these, however, must be set the new resources and techniques that science itself has furnished for the unending battle against the destructive effects of age and the environment.

Conservation of one kind or another, then—and this is the only point that is being made—is very much a topic of the times. (One rather curious aspect of this preoccupation is the fact that everyday household objects which only twenty or thirty years ago we were accustomed to use and dispose of without a second thought have now become things to be conserved and prized as objects of antiquarian value. In the age of plastics, the simple fact that a thing is made of wood or iron or glass may seem reason enough to preserve it from decay and destruction.) Now museums are institutions that have conservation as part of their *raison d'être*. And this part of their function takes on an added significance as in so many areas, for one reason or another, the opportunities for collecting on any extensive scale diminish or disappear. Under such circumstances the preservation and conservation of what we already have becomes even more vitally important than before.

There may even be a rather pleasing paradox to be discerned in all this. By their devotion to the cause of conservation, museums, which to the popular way of thinking have generally been thought to be oriented towards the past, may now at last be seen to be in the vanguard of a movement of worldwide concern for the future. Perhaps the world is only now catching up with its museums!

The threats to museum objects with which a conservator must contend are, as you will read in the pages that follow, many and varied: harmful atmospheric conditions, vandalism, infestation, misguided attempts at repair or restoration by former owners, and many others. The very passage of time itself represents a threat. "To leave a thing alone," wrote G. K. Chesterton, "is to abandon it to a torrent of change." Things simply do not stay put; and even the careful and dedicated efforts of conservators can serve only to retard the unremitting and all-encompassing process of decay and dissolution.

"What is there that pernicious time does not make worse?" asked Horace. So impressed were the ancients by the universal decadence of things that they erected a whole cosmology upon it, interpreting all the history of the universe as a constant deterioration towards eventual dissolution, from which state it would be restored to its pristine condition by an act of divine intervention so that the whole cycle could begin again. However, the cycles were very long ones; meanwhile the modern museum conservator must do what he can to arrest the universal process with the available scientific techniques.

In one respect, at least, Horace seemed to believe that he had outwitted the destructive processes of time. "I have finished a memorial more enduring than bronze," he wrote of his poetry. If he had had a chance to talk to the ROM's Carol Jack, he might have chosen a different standard of comparison. Bronze, too, as she points out in her article, is subject to the hazards of age.

The work of the ROM's Conservation Department is the theme of this issue of *Rotunda*. It was quite a long time ago that the editors of the magazine first approached the department with a suggestion for an article about this vitally important but perhaps insufficiently known part of the ROM's work — insufficiently known because, in the nature of things, most of the Conservation Department's work takes place behind the scenes. However, it soon began to appear that a single article could hardly do justice to the scope and variety of the topic. The editors therefore agreed to the department's suggestion that it should be given the freedom of a whole issue in which to give *Rotunda's* readers some insight into their activities. From the articles that follow, the reader will gain some idea of the variety and complexity of the problems faced by museum conservators and of the range of knowledge and skills needed to tackle them. These problems have undoubtedly been compounded for ROM conservators by the far from ideal conditions that prevail in the present building. In the renovated and expanded museum the department can look forward to a much more favourable and rewarding environment for its efforts.

There is a verse in a popular hymn that runs: "Change and decay in all around I see..." Next time I sing it I think I shall hear with my mind's ear the voices of the ROM's Conservation Department rejoining in unison, "Not if we can help it."

THE EDITOR

Rotunda, Vol.10, No.3 (Fall 1977), proved to be such a popular issue that the printing has been completely sold out. The following two articles from this issue, however, are available as Rotunda Reprints: **Some Bones of Contention – The Neutral Indian Burial Site at Grimsby**, by W. A. Kenyon (with colour illustrations, $1.00); and **Not Ours to Control – Living with Changing Lake Levels**, by Walter M. Tovell (50¢). A discount of 20% will be given on quantities of ten or more of either title. Please send payment with order and add 10% of amount (minimum 15¢) for postage and packing. Mail orders to Rotunda, Publication Services, Royal Ontario Museum, 100 Queen's Park, Toronto, Ontario, M5S 2C6.

The Decorative Arts and Ethnology Conservation Laboratory.

Through the Eye of Time

The Work of the Conservator

Elizabeth Phillimore

THE COLLECTIONS OF THE Royal Ontario Museum are a unique multi-disciplinary resource containing examples of all natural and man-made materials, exhibiting countless variations in form and purpose and gathered from every geographical region to which man's quest for knowledge has led him. Time, however, is an inexorable destroyer of matter, and nothing remains static. Given enough time and the stimulus of an enviroment conducive to decay, all "things" journey back, at different rates of decomposition, to their origins.

Living materials, wrenched from their quiet cycle of transmutation by man the artist, are cut, carved, pounded, traumatized by fire, melted, cast, spun, woven into a thousand variations of form, to become the manifestation of a craftsman's idea — an object. The original form disappears, the original life cycle is broken, and a second life cycle begins. Thus, created in the past for purposes of usefulness, worship, beauty, fear, or status, objects fulfilled the roles for which they were made. If deterioration or breakage occurred, they could be replaced, probably by use of the same readily available materials and local skills.

But time passes, and in the course of change through natural or man-made disasters, the operation of trade, and the shift of cultures, most of these objects are lost. However, some eventually find their way into museums, where a kind of third life begins. They have now become "cultural objects" representing some segment of the sequence of man's development, the tangible evidence of a once-flourishing culture. Now time must stop, and it becomes the responsibility of a museum to maintain the object unchanging in this third life, to preserve its original integrity intact so that it may help us to learn about the culture from which it came. It is an acknowledged obligation of each generation not only to study these source objects and interpret them, but also to ensure their physical survival so that future generations may know "what has gone before". The modern conservation department has fallen heir to this second responsibility: the physical well-being of the collections.

While it is true that all things decay, deterioration can be prevented to a considerable degree if the agents

Top: Inuit carving made from a cross-section of a walrus tusk.

Bottom: Detail view of ivory Chinese picnic basket, showing the delicate slits used to relieve stresses in the ivory.

causing it are identified and understood. Thus conservators must comprehend and interpret the interaction of four factors: the materials from which the object was made, how these were modified and combined by the original craftsman, the environments the object has come from and passed through, and the amount of time that has passed since it was made.

The fact that most natural materials have a known range of consistent behaviour is a great help in this determination. For instance, we know that wood has the vertical strength of a tree, that it needs moisture to maintain its dimensional stability, and that nature has arranged for it to rot fairly rapidly underground. We know that metals are dense, that they melt at different temperatures, and that most of them form surface coatings or tarnish when exposed to certain gases, resulting in discoloration and eventual corrosion. We know that glass is brittle and decomposes into layers that refract light into prismatic colours. We know that paper and silk deteriorate rapidly in strong light and that many natural dyes fade. Through a combination of constant vigilance and research, we have learned to recognize and interpret these and a thousand other quirks of material behaviour. This kind of exploration

and discovery is one of the most exhilarating aspects of conservation as a profession, and the accumulation of this knowledge and experience forms the strong base on which judgements are made regarding preventive care and treatment.

One interesting facet of the known behavioural range of materials is their structural memory. A semi-circular sheet of ivory or wood, pared from a tusk or a tree, may be steamed and flattened for use in a miniature painting or a musical instrument. If the objects are then kept for some time in hostile environments, the materials will free themselves from their imposed flatness and, remembering their original circular shape, will revert or "warp". Examination of artifacts from many regions reveals that the indigenous craftsmen who made them were highly attuned to their material and to the limitations it placed upon their modification of it. The development of their forms and methods was often dictated by the nature of the material. The carving illustrated was made from a slice of walrus tusk, whose hollow, circular shape was used to advantage to form a ring of dancers.

However, as civilizations became more complex, more hierarchical, and more acquisitive, the striving for something new and different often drove artists and craftsmen to use materials in ways that were completely contrary to their natures. The caprice was a challenge then, and it still is. Some of our most beautiful, as well as some of our ugliest and most absurd, creations have been the result of just this eccentric use of materials. The ivory picnic box illustrated is made of very thin, flattened sheets of ivory. The Chinese craftsman who made it cleverly released the surface tensions inherent in the original curve by cutting an elaborate pattern of slits through the ivory sheets. This was fairly successful until the box came into our unstable climate.

Craftsmen have always taken calculated risks, and it can be said with some assurance that one of the factors they took into consideration was, and is, the response of their material to its climate. An Inuit seal hunter "knows" his greased skin kayak will be watertight in the icy waters and cold air of the Arctic. Small wonder though that it cannot survive intact if it is taken out of the water and moved to a museum climate, which is radically different in temperature and relative humidity.

Historical evidence shows that from very early times artifacts have moved freely between cultures. In recent centuries large numbers of people have been forced by war or have chosen for social, religious, or educational reasons to travel all over the world, and there has awakened in them an interest in things "exotic" and "foreign". The much-publicized "romance" of archaeology stimulated an interest in ancient civilizations, and everyone from 19th-century missionaries to 20th-century back-packers brought things home. Napoleon's Egyptian campaign in 1798 resulted in the transfer of delicate Egyptian antiquities from the hot dry desert climate of Egypt to the cold damp winters of the Louvre Palace in Paris. Missionaries working in Africa or the Orient brought home carvings from the steaming jungles of the Congo and delicate lacquered screens from the cool dampness of Japan, to survive as best they could in environments that were totally different from the ones they were designed for. Emigrants rolled and folded paintings to fit into suitcases, and took icons, musical instruments, and inlaid furniture from dark cool houses in Europe into the shock of North America's overheated buildings. As recently as the 1960s the influence of the Beatles led a generation of young people to explore Eastern religions. One outcome of this was the sudden appearance in the Western world of a large number of Tibetan *tankas* and Asian textiles, which they brought home from their pilgrimages to Kashmir, Afghanistan, and India.

The environmental shock caused by transplanting objects to hostile conditions often results in extensive damage. Conservators can do two things to alleviate this: first, they can take all the steps necessary to prevent any further deterioration or abuse of the object caused by poor environment, and second, they can apply treatments that bring the object, as near as possible, to what they perceive as its originally intended state. Preventive conservation is concerned with the physical environment an artifact occupies in gallery or storage areas. Museums that request loans of ROM material are screened prior to loan approval for their ability to provide the proper environmental controls in their galleries.

Artifacts are most comfortable in environments as nearly akin to their original ones as possible. Organic materials are most affected by instability of temperature and relative humidity (RH). The climate of the present ROM galleries varies from 32°C/90% RH in late June to 23°C/10% RH in January. Organic materials are like a sponge. When the relative humidity is high in summer, each thirsty fibre absorbs moisture, and the material expands, causing cracks in furniture to close, stiff leather to soften, and the canvas of paintings to sag. When winter comes and the humidity drops, materials are forced to give up their moisture, and the fibres shrink again. If the shock of this change is sudden, new stress cracks will appear as the material struggles to adapt. When this expansion and contraction is repeated annually in response to uncontrolled climatic changes, permanent damage is inevitable.

Fortunately for the future of the ROM collections, the museum expansion and renovation programme will provide climate controls in the new galleries and the curatorial centre. It will not be possible, however, to put large amounts of moist air directly into the renovated galleries of the existing East and West Wings without endangering the building fabric. If the inside surface temperature of the outer wall of a masonry building drops below the dewpoint in winter, a high internal humidity will cause frost to

form within the walls, causing deterioration of the building materials. At present the ROM is exploring the possibility of building enclosed environmentally stable "micro-climates" of various sizes in which to display moisture-sensitive collections, and maintaining only in the observer space a climate that the building fabric can accept.

In February of this year, under the joint auspices of the Conservation Department and the Exhibits Communication Task Force, the ROM brought together for three days a group of planners, designers, engineers, and conservators to study all aspects of micro-climates. The results of this meeting were highly satisfactory and led to the establishment of definite parameters for the development of prototypical cases and equipment.

Another aspect of preventive conservation is the control of light. Light does three things to materials: 1) The ultraviolet wavelengths in sunlight and fluorescent tubes cause fading of organic materials as different in nature as dyed porcupine quills and Japanese lacquer. 2) Strong light causes photo-chemical degradation: light is energy, and that energy induces excitation and consequent radical movement of the molecules in organic materials, so that eventually the material literally wears itself out. 3) The infrared wavelengths of light create heat, which can build up inside an exhibit case causing a sharp rise in temperature. For instance, when the hot sun hits the exhibition cases in front of the museum building at 8:30 A.M. on an April morning, the internal temperature of the cases rises from 3°C to 44°C by noon.

Moreover, dark surface areas absorb heat, whereas white surfaces reflect it. Infrared wavelengths cause a rise in the surface temperature of a dark object, or of dark areas directly adjacent to light areas in a pattern of decoration. These variations in surface temperature create internal stresses and damage. Consequently organic materials are displayed under low light levels. Visitors to the ROM exhibition "In the Presence of the Dragon Throne" may have realized that the exhibition was designed to maintain light levels of no more than 50 lux, the maximum allowed for perishable silk.

I have touched on some of the important aspects of preventive conservation. In the following articles my colleagues will be describing some aspects of treatment in their own areas of specialization.

We live in a time of increasing specialization, with its well-known attendant dangers of tunnel-vision and resulting difficulties in communication. In the museum world, multi-disciplinary institutions like the ROM grow more unusual with each passing decade, as uni-disciplinary units split away from the hurly-burly of "family" museums in which arts and sciences interrelate under one roof. The ROM programme of expansion and renovation of galleries is providing us with a unique opportunity to examine and build on some of the hitherto undiscovered possibilities for communication within these inter-disciplinary relationships. This is possible only because our huge resources are comprised of not only the visible array of natural and man-made phenomena in galleries and study collections, but of the invisible factor of staff expertise, which reaches past the apparent into dimensions beyond the bounds of existing knowledge. These two resources of human expertise and the collections it interprets are the strength of any museum. The place of the Conservation Department in this scheme of things is to protect and maintain "the real thing" so that the knowledge it embodies may be reliably available to present and future generations.

Elizabeth Phillimore came to the Conservation Department of the ROM in 1958. She is a practising artist trained in Canada and England, and for 18 years was a conservator of decorative arts and, later, paintings. Since July 1976 she has been head of the Conservation Department and is at present deeply involved with several aspects of planning for expansion.

Djed-Ma'at-es-ankh before treatment.

A Real Case History

The Coffin of Djed-Ma'at-es-ankh

Susan Wilson and Carol Baum

THREE CONSERVATORS had gathered in the Decorative Arts Conservation Laboratory to perform the task. With one conservator at each shoulder and a third at her heels, Djed-Ma'at-es-ankh was inched feet first off the padded workbench and gently tipped upright onto the floor. For the first time in many years the inner-case coffin of the 9th-century B.C. Egyptian lady was standing. Safe attainment of the new position for the 100-pound form marked the successful completion of two months' work by two conservators.

As part of the proposed renovation of the Egyptian Mummy Gallery, several coffins are to be displayed upright. To ensure their well-being and survival in this new position, conservation treatment is necessary. None of the ROM's coffins has undergone treatment since acquisition, and it was decided last year to examine, clean, and treat all of them. Conservation began with the coffin that still houses the mummy of Djed, as she affectionately became known to her conservators (see Dr. N. Millet's article "An Old Mortality: An Egyptian Coffin of the 22nd Dynasty, *Rotunda*, Spring 1972).

In appearance, construction, and physical characteristics, the inner-case coffin of Djed-Ma'at-es-ankh resembles a plaster cast, but there is a difference — gesso rather than plaster was used in its construction. Gesso is a combination of powdered chalk and animal glue, which is readily soluble in water. The coffin case was not formed around the Egyptian lady. Instead many layers of linen saturated with gesso were moulded onto a mummy-shaped wooden form, and when this cartonnage was dry, it was slit down the centre back and removed from the form. The mummy was then inserted into the cartonnage, two boards were dowelled into the hollow opening at the foot of the cartonnage, and the long incision down the back was laced up with string. For added strength the back seam and the footboard edges were covered with strips of gesso-soaked linen. Finally, the entire coffin was given a coat of gesso to provide an even surface and the coffin was brightly decorated with portrayals

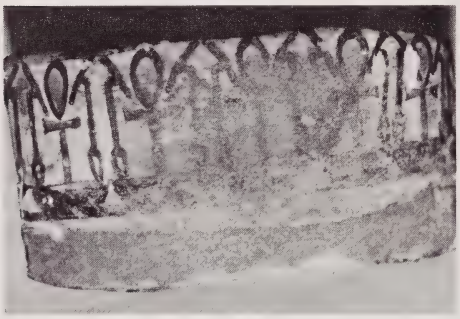
of deities and iconography associated with the attainment of the afterlife. These decorations were executed in water-soluble paints and some of them are protected by ancient Egyptian varnish. The highlight of the coffin is its exquisite gilded face.

Careful examination of the cartonnage indicated the need for three major treatments: the coffin would have to be cleaned, a loss in the nose would have to be filled and regilded, and the foot region would have to be stabilized so that the coffin could be upended.

While the sides and back were surprisingly clean, the upper surface was very dirty. Over the years a thick coating of dirt had settled on the case and adhered to the surface, and no amount of dusting could remove this age-old grime. On the ends of the toes there was a deposit of mud, and the coffin surface had some very disagreeable deposits of bat excrement, which had accumulated while Djed was still in her tomb. Moreover, bat urine had collected on the surface and in some places had dissolved mud and excrement, and even paint and gesso where they were unprotected by varnish. This solution had soaked into the cartonnage and dried there.

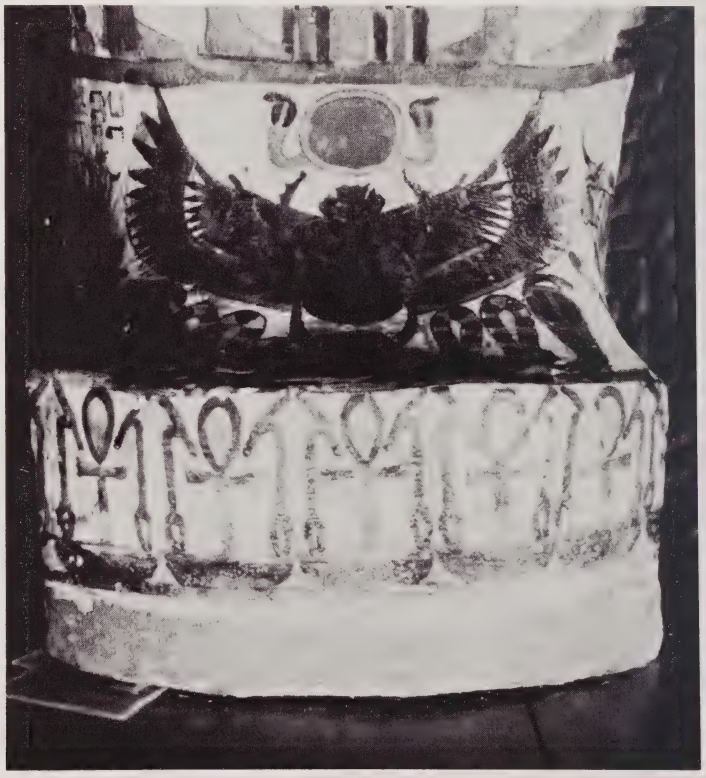
Nonetheless, much of the cleaning operation was easy and very rewarding. It was not difficult to remove the dull grey dirt of ages from the surface to reveal the bright colours and white cartonnage beneath it. The job was done in a day, with nothing more complex than art gum erasers. Deposits of bat dirt and mud were readily removed from areas that had been varnished. Because this varnish is a finish that is not water soluble, small water-dampened cotton swabs were used to roll away the grime. Water, however, was out of the question for the toe region, which was only sporadically varnished. Fortunately, the mud here was in a thick encrustation, which was removed successfully, though slowly, by chipping away at it with a blunted dissecting needle.

The areas of difficulty were those in which mud and dirt had been dissolved together and had soaked into the water-soluble paint and the cartonnage. Careful examination revealed that in most places the dissolved dirt had not completely mixed with the dissolved paint and gesso. It appeared that as the bat urine evaporated, the two layers had bonded tightly together, with the mud layer on top. The problem was to find a means of removing the mud without harming the paint and gesso beneath it. Many techniques proved inadequate, since despite meticulous care, some paint was removed. No solvent other than water was found that would dissolve the mud, but the action of water was too rapid for selective dissolving of the mud alone. Eventually, however, the near-perfect agent was discovered — the conservator's favourite solvent, spit! The viscous quality of saliva makes it easier to control in application and slows down the solvent action. Thus, with well-sucked swabs, the dirt was carefully lifted from the unvarnished areas of the coffin. Only in places where the paint had smeared badly or where discoloration caused by dissolved



Above: The front of the toe region before the mud was picked away.

Right: The front of the toe region after the mud was picked away.



Left: Crushed linen at the left heel, revealed when the left plank of the footboard was removed.

Below: Bulldog clips and thin Plexiglas were used to straighten the linen.

paint or urine had soaked deep into the cartonnage did this method fail, and these areas had to be left dirty.

Much of the nose, both gesso and gilt, had been lost, and with it much of the appeal of this colourful lady. Conservators hesitate to replace missing areas of artifacts, except where fills are necessary to maintain an object's strength. In this case, however, both the Egyptian Department and the two conservators agreed that replacement of the nose, a purely aesthetic additon, would enable the artifact to better fulfil its museological role. Accordingly, the missing areas of the septum, bridge, and nostrils and the end of the nose were carefully built up with gesso, to which Van Dyke brown pigment had been added. There were several reasons for using a brown gesso. The fill would be readily distinguishable from the original both because of the difference in colour and because Van Dyke brown was not used in ancient Egypt. Moreover, the gleam of pure white gesso makes shapes modelled in it appear to be larger than in fact they are. With a toned-down medium, the correct proportion for the new nose was more easily achieved. Its shape was determined by carefully continuing the contours of the existing parts and rounding off the end where the slopes met. The fill was water-gilded with two layers of modern gold leaf, which was toned to match the original with a light watercolour wash of Van Dyke brown.

As the coffin is to stand upright, the structure of the foot region had to be made sound, for Djed's footboard, composed of two boards dowelled together, was very insecure. The gesso that binds the linen layers together and holds them stiff had somehow been lost from the back region of the left heel. The linen remaining in this region had been crushed in under the footboard and provided no support to the rear of the left plank. Furthermore, the mummy had slid down inside the case and was exerting considerable strain on the join between the cartonnage and the footboard. Sometime in the past there had been an attempt to consolidate the footboard with plaster and cement, but this old repair was both ineffective and unsightly.

Days of thought were devoted to the problem of what method to use in repairing the foot region. No literature on the repair of cartonnage coffins seemed to exist, nor had conservators in other museums possessing Egyptian coffins dealt with a similar problem. With no example to follow, it was decided that the loose left plank of the footboard should be removed so that the structure of this critical area could be properly examined, with the hope that in the course of this study a solution would present itself. This decision was not lightly made as there were certain hazards involved. Removing the left plank would do some slight damage to the coffin. There was an inch of linen tape still intact at the front of the left board, which

Profile of the gilt face of Djed after the nose was rebuilt and regilded.

would have to be cut. Prying the board free of the dowels that held it tight to the neighbouring board might cause further damage, and, as always, there existed the possibility that the two boards, once separated, would not go back together.

Dislodging the left board did indeed prove difficult. First, the stubborn old cement repairs had to be scraped away. Next, to prevent fraying when it was cut, the inch of linen tape was strengthened by the application of a concentrated solution of a clear adhesive, and a scalpel was used to make the incision. Finally, the left board was levered out of its cartonnage housing and pulled sideways off the dowels that held it to the neighbouring board. In the process a dowel on the cartonnage side of the board had to be severed.

The result of this risky procedure was success, as no further damage accrued, and revealing the interior of the coffin produced answers to all problems. It was found that the turned-in linen of the deteriorated cartonnage, though crushed and brittle, was nearly complete and in quite good condition. Furthermore, the thickness and strength of the edge of the cartonnage, where intact, were judged to be sufficient to support the entire coffin's weight, particularly if the crushed linen were straightened and new gesso introduced into it. The last problem to solve was how to move the mummy back up into her original position in the coffin. Gritted teeth, crossed fingers, and a quick shove did the trick.

Repeated wettings and gentle coaxing restored the crushed linen to its original contour. After the final dampening, a piece of thin Plexiglas was clipped inside the wet linen to hold it in shape as it dried. A recipe for ground used in medieval European panel paintings supplied the formula for the new gesso used to consolidate the linen. The footboard was eased back into place, and new cartonnage was added to make up the edge loss around the foot. In building up new layers of cartonnage, linen from old tea towels worked best, for the material readily absorbed the gesso and was easy to manipulate. Finally, a strip of new, finely woven linen (which had been dyed in tea so that it would harmonize with the colours of the existing cartonnage) was cut with meticulous care to cover exactly the areas of repair. It was fixed in place with gesso. So that the eye would not be distracted by a break in the decorative banding at the back of the heel, the missing design was inpainted with watercolours.

Djed-Ma'at-es-ankh, refurbished and clean, is once again lying in the Egyptian Mummy Gallery. When her home has been renovated, she will be displayed upright so that everyone can fully appreciate her magnificence.

Right: Susan Wilson, wood conservator, joined the Conservation Department in 1974 after completing a master's degree in conservation at New York State University. She also has B.A. and Master of Museology degrees from the University of Toronto.

Centre: Djed-Ma'at-es-ankh was a chantress in the temple of Amun-Re, Thebes, 32 centuries ago. She became a member of the Egyptian Department in 1910.

Left: Carol Baum, conservation technician, was hired to work on the Egyptian coffin project with Ms. Wilson. She is a graduate of the woodworking programme of the School of Crafts and Design at Sheridan College.

A Hundred Years of Dirt

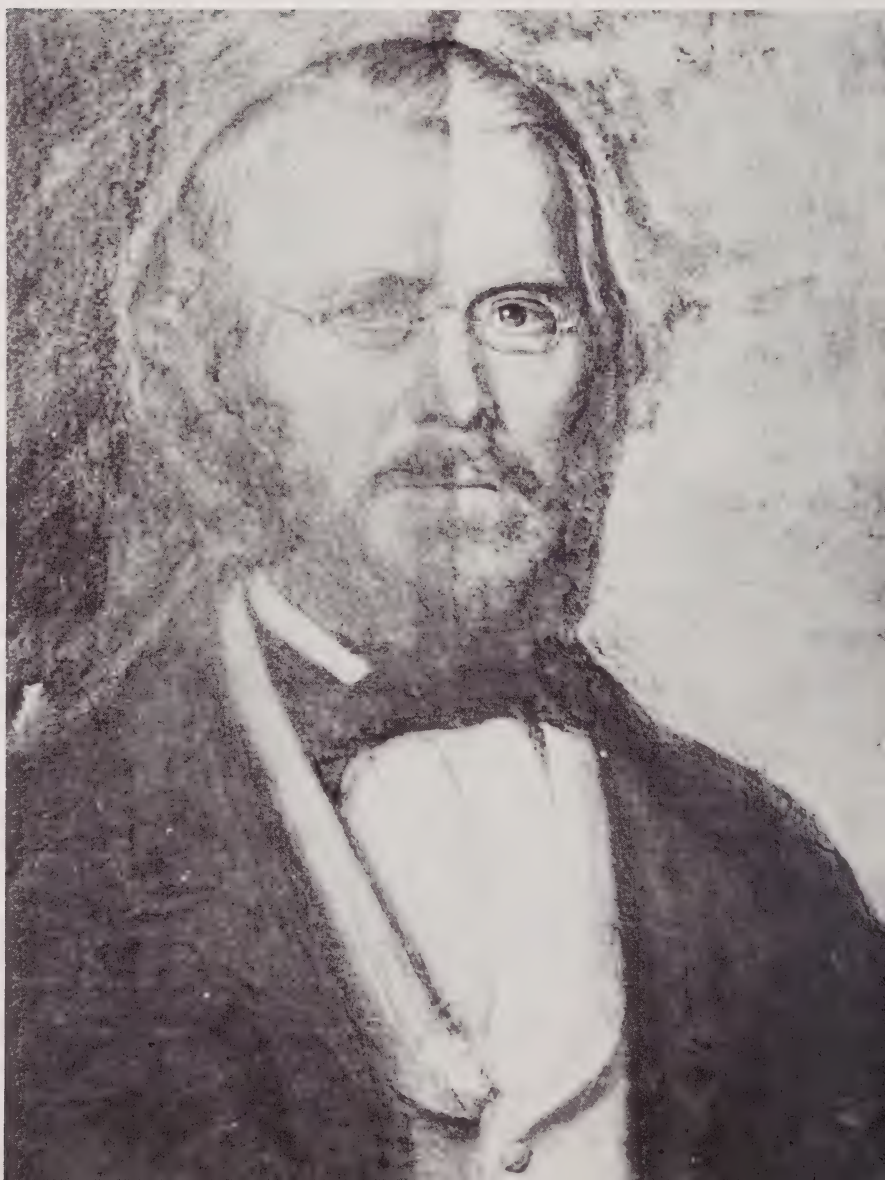
Conserving an Early Canadian Portrait

Diane McKay

Above: Emmanuel Playter before treatment. The thick surface dirt obscures all detail. The two white patches on his vest are test areas where the dirt and varnish have been removed.

Right: Emmanuel Playter during treatment, half surface-cleaned.

Opposite page: Removing the surface dirt.



DECADES OF DIRT obscured Emmanuel Playter's countenance when he arrived in the laboratory of the Conservation Department. Gradually he began to see daylight again as layers of grime and discoloured varnish were removed. This then is an account of the portrait's enlightening experience as it went through conservation treatment.

The oil portrait on canvas was a gift to the Canadiana Department from one of Emmanuel Playter's descendants, Mrs. R. L. Mudge. The original Playters were United Empire Loyalists who were given a sizeable grant of land along the Don River between Bloor Street and Queen Street, and Emmanuel (1798–1868) eventually inherited some of this property. His portrait was painted in 1861 by an artist called Löffler, but there were two portrait painters named Löffler in Toronto at that time and we do not know which of them executed Emmanuel Playter's likeness.

The portrait arrived in the Conservation Department framed and, as is customary, it was first photographed just as the conservator received it. The frame had been painted a number of times with various tones of gold, and the gesso moulding had been chipped in many places by rough handling, a common condition in old frames. In the top corners of the frame there were gold-painted triangular pieces of heavy cardboard, which made the opening at the top arched rather than rectangular. To hold the painting in place, nails of the type in common use in the 19th century, square-sided with pounded heads, had been driven into the back of the frame and the strainer.

So that the painting could be properly examined and its condition noted, it had to be removed from the frame. Once that was done, the approach was from the underside up, and the first "layer" to be examined was the auxiliary support for the canvas, a wooden strainer with mitred corners, which had many random nail holes in it.

Next came the support for the paint layers, a very thin linen canvas tacked onto the strainer. On the underside, discoloration was evident down the centre of the canvas, probably the result of an earlier attempt to wash Mr. Playter's face and shirt. The linen was very brittle and it had two tears, one at the top edge where the canvas turned over the strainer, and the other in the area of sky above Mr. Playter's right shoulder. Running across the lower edge of the canvas was a firm bulge, which indicated that something was caught between the canvas and the strainer bar.

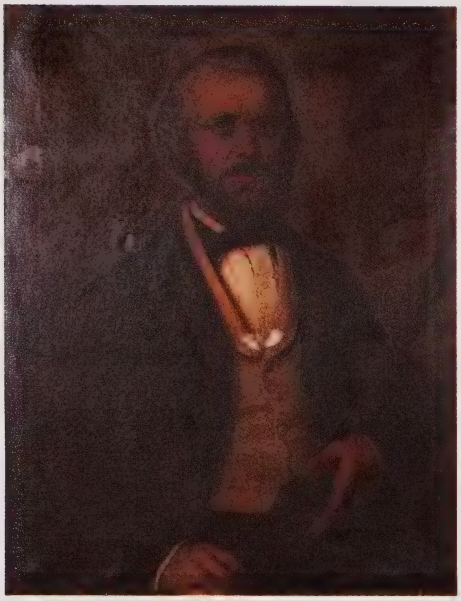
The layer of white ground on the canvas was very thin and very uneven at the turning edges. It was probably applied by the artist since a commercially grounded canvas would have had a solid layer of ground that continued over the tack edge to the very perimeter of the canvas. In general, the paint layers were firmly attached and did not pose a problem. Some paint losses had occurred around the tears, but they were very slight. While cracks were not extensive, there were strainer marks on all sides, except the lower bulging edge, indicating that the canvas had sagged and come to rest against the strainer bars. There was also abrasion all around the edges where the painting had been held too tightly in the frame.

The surface coating, a varnish, had been applied unevenly, and in addition to being very yellow it was covered with a thick layer of obscuring dirt. Around Mr. Playter's head there seemed to be a curious halo. Here the dirt was less thick, and there were dull spots where the varnish had been removed, further evidence that an earlier attempt had been made to wash the face and shirt.

The proposed conservation treatment was fairly straightforward: 1) remove the surface dirt and discoloured varnish; 2) return the edges of the tears to plane and fill in the missing portions; 3) flatten the

Below: Emmanuel Playter before treatment.

Right: Emmanuel Playter after treatment: lined, retouched, and varnished.



bulging areas; 4) line the painting to provide support for the weak and brittle canvas generally and the torn areas particularly; and 5) retouch and revarnish the painting. The most difficult and time-consuming operation would be the removal of dirt and varnish. Before cleaning could be started, it was necessary to test proposed cleaners, solvents, and adhesives on tiny, unobtrusive spots on the painting, to ensure that they did not damage the work of art.

Although some of the dirt came away with plain distilled water, it was found to be faster and more efficient to use solutions of distilled water and a special detergent in various strengths. During the cleaning, the canvas was supported from below to prevent any movement that might crack the paint. Needless to say, the cleaning improved Mr. Playter's appearance immensely. Details of his coat and the gun lock reappeared distinctly, as did the background hills and trees. Particularly exciting was the affirmation of the Löffler signature, a bit below and to the right of Mr. Playter's elbow. Unfortunately, an initial, which would have established which Löffler painted the portrait, could not be unearthed.

Once the tenacious layer of surface dirt was gone, removal of the varnish was made much easier. A number of mixtures of organic solvents were tested to determine which one would be best for dissolving the varnish — without taking the paint too. Finally one mixture was settled on, and it was used in three strengths. The procedure for removing the varnish was the same as that used for removing surface dirt. "Q-tips" moistened with the mixture were applied to the varnish with a gently rolling action and then the area was wiped with a less active solvent or restrainer. Throughout the two operations photographs were taken to record each stage. Especially important were the ultraviolet photographs, since long wavelength ultraviolet rays cause varnishes to fluoresce and make it possible to check how much varnish remains on the paint surface.

With the most difficult part of the treatment completed, work could begin on readying the canvas for lining. The tear above Mr. Playter's right shoulder was dealt with first. After the dirt was brushed away from behind it, a barely damp cotton swab was rolled over the back to soften the torn edges of the canvas; blotters were used to absorb any excess water. This dampening made the edges flexible so that they could be aligned, and then the area was allowed to dry under weights overnight. Any depressions were filled with gesso, and this too was given time to set and dry out. A small piece of facing tissue was applied to the

front of the tear to reinforce and protect the fragile area while the entire back of the canvas was being cleaned.

The back of the painting, too, had its share of dirt. When the strainer was removed, it left behind a white "ghost" of its shape, because dirt and dust had seeped through even the tiniest openings and adhered to the back of the canvas. Dark lines were visible where grime or possibly smoke had penetrated the very narrow slits between the spread mitres of the strainer. At the lower edge, years of dust, pine needles from Christmas decorations, dirt, and seed pods had collected — to a depth of an eighth of an inch in places. No wonder Mr. Playter was bulging! This debris was removed, and the back of the painting was gently vacuumed to pick up any residue. The turned tack edges were gradually flattened by repeated pressings of the creases with a warmed tacking iron and wax-resin adhesive.

Next came the lining, which usually involves three steps: 1) The lining canvas is stretched and washed to remove any sizing, and when it is dry, wax-resin adhesive is melted into it. 2) The painting itself is impregnated with the adhesive. 3) The painting is placed on top of the lining canvas on a hot table, heated to melt the wax-resin, and the two canvases are allowed to cool under vacuum to ensure a complete bond. In Mr. Playter's case, a very fine mist of distilled water was sprayed onto the hot table before the painting (its back already brushed with wax-resin) was placed on it for impregnation. This small amount of moisture helped to relax the canvas so that the bulges at the lower edge flattened considerably, although they did not disappear completely. Consequently, water was lightly sprayed onto the table a second time before the lining canvas and the painting were fused under vacuum. The vacuum was not turned on until the wax had melted thoroughly and the paint layers had softened somewhat, so that its pressure would not break and crush the brittle paint.

Once the painting was lined, excess wax was removed from the paint surface, and the protective facing over the tear was taken away. The painting was then stretched onto a new stretcher, and a brush coat of synthetic resin was applied to give the painting an even intensity over its entire surface. This isolating varnish, as it is called, also serves to separate the conservator's retouching from the original paint layers, although Mr. Playter required very little retouching. The greatest paint loss was in the area of the tear above his right shoulder, and even it was slight. The abrasion on the edges required some inpainting as well. Dry pigment and a synthetic resin varnish were used for retouching. Then two coats of synthetic varnish were sprayed over the entire painting to provide a final protective covering for the paint layers and to give the painting a unified appearance.

Although Mr. Playter was at last conserved, there remained some tidying up to be done on his frame. The warped triangular pieces of cardboard were flattened, but as they refused to remain flat new pieces had to be cut and inserted. Their undersides, and the rabbet, were lined with felt to prevent any further abrasion to the edges of the painting. The worst of the losses in the frame were filled with gesso, and an attempt was made to blend its colour with the various shades of gold already present. Finally, a protective sheet of "Fomecor" was stapled to the stretcher to cover the back of the painting and to prevent any objects from slipping in behind and causing further bulging. Then Mr. Playter was returned to his frame, and brass mending plates, extending halfway across the stretcher members, were screwed into the frame to hold him securely in place.

With the accumulated dirt of decades removed, and the yellowed varnish gone, Mr. Playter's outlook has been much improved — and we in turn have a much better view of him.

Diane McKay is a paintings conservator and has been with the ROM for a year and a half. She received both her B.A. (Honours) and her Master of Art Conservation degrees from Queen's University. Her first ROM project was assisting Elizabeth Phillimore in the conservation of Benjamin West's painting "Death of Wolfe". She has also worked at the National Gallery of Canada in Ottawa and as part of a team working for the National Gallery on the removal of wall paintings from a Nova Scotian house.

An Ekoi Mask with Skin Problems

Julia Fenn

THE ETHNOLOGY DEPARTMENT OF THE ROM possesses a splendid ceremonial mask from the Ekoi tribe of Nigeria, which has suffered the vicissitudes of an unfriendly environment.

To attain the appearance of flesh in such masks, a damp monkey skin (formerly human skin was used) is stretched over a pieced wooden core carved in the form of a face. The skin is then shaped to the contours of the wooden face with a piece of heated metal.

As it dries, the skin shrinks until it is stretched taut over the carved areas. It is prevented from pulling away at the corners of the eyes, nose, mouth, and ears by small wooden pins. In the last stage the ridges of the hairline, eyebrows, and tribal markings are emphasized with a dark resinous paint.

In the humid climate of Nigeria the skin remains supple and will cease to shrink as it becomes acclimatized. Unfortunately, when such a mask is taken to a drier climate, the skin—already under considerable

Opposite page: The mask in 1957: the skin has split across the bridge of the nose and on the "horns", but is otherwise intact.

Left: The mask in 1978: the crack over the nose has widened and extended across the temples towards the ears. There are new splits on the right cheek and on the neck just below the chin.

tension — dries out more and continues to shrink. At the same time it becomes less flexible so that it can no longer stretch to accommodate the additional shrinkage.

The wooden core is slower to dry out as, unlike the skin, it is not directly exposed to the atmosphere. Because wood shrinks far more across the grain than along it, the pieced core shrinks away from the skin in some areas, without relieving the pressure in other directions. Since the wood and skin are not shrinking at the same rate, to the same degree, or in the same directions, tremendous tensions are set up, which result in the skin's bursting apart.

As can seen from the photographs, this Ekoi mask has been tearing itself apart over the years. This disastrous process will continue unless we can find ways of protecting this fine mask from the vagaries of the Canadian climate. We hope to achieve this through improved environmental control when the ROM galleries are renovated.

Julia Fenn is ethnographics conservator (part-time) and has been associated with the ROM for two years. A graduate of Cape Town University and the Institute of Archaeology in London, she has previously worked at the British Museum and at National Historic Sites in Ottawa. She is at present head of the conservation technician training course at Sir Sandford Fleming College in Peterborough.

Complex Problems in Conservation

A Flemish Tapestry

Izabella Block-Bolten

THE CONSERVATION of a textile begins with an examination, on the basis of which the conservator makes a decision regarding treatment. Sometimes the proposed treatment will require more time than usual, sometimes more people, and sometimes more space, but seldom do all three requirements arise in the treatment of any one artifact. In the European Medieval Gallery of the ROM, however, hangs one of the occasional exceptions to that norm — the Flemish tapestry, which dates from the early 16th century and depicts scenes from the Trojan War.

The Flemish tapestry is made of wool and silk, both in very poor condition, and it is so unusually large (6.55 metres long by 3.50 metres wide) that it poses every possible problem. Its conservation would require more time than any other textile object in the museum and extra people to work on the tapestry. Since there is at present no working space large enough to accommodate the tapestry, the question of financing the undertaking also arises. To add to all that, a good deal of thought would have to be given to what *kind* of conservation method to use.

To understand the problems involved in the conservation of the Flemish tapestry, we have to know what tapestry is. Technically, tapestries are woven textiles, usually in the form of wall hangings, with patterned and figural respresentations. The undyed warp is completely hidden, and the weft makes the pattern. (The warp threads are stretched on the loom and are therefore stationary; they are crossed by the weft threads.) Tapestries differ from other woven artifacts in that no weft thread is carried over the whole width of the textile: each area of colour is built up separately, that is, the coloured weft is woven only in the section where that colour appears. Where the

Opposite page: Upper half of Cassandra(?). Notice the damaged area on her shoulders and the rewoven area in the hair.

Right: The rehanging of the tapestry was a difficult job, requiring the services of eight preparators.

margin of colour is straight and parallel to the warp, a slit is left, and there are several different ways of closing these slits. In the Flemish tapestry, as in many European tapestries from the 14th century on, the slits were left open on the loom and sewn up afterwards.

All tapestries are woven so that when they are hung on a wall the warp runs horizontally and the weft vertically. Thus the vertical weaving of the weft thread begins from the side of a pattern, and this gives a definite aesthetic advantage since the horizontal ribbed texture created by the thick warp reflects the light better. The method also has a technical advantage, as in the course of the weaving it is easier to control proportions, especially in the representation of the human figure. On the other hand, this side-to-side method of weaving used in tapestries is one of the principal factors in their deterioration. The tapestry hangs on the weft thread, which is significantly finer than the warp thread and therefore more susceptible to damage.

In the past year a first step was taken towards the preservation of the Flemish tapestry. At the request of the Conservation Department, it was removed from the wall so that it could be examined and a condition report made. For three days it was spread flat on the floor of the Bishop White Gallery, the only space in the museum large enough to accommodate it horizontally. Three days was set as the maximum period for examination and minor repairs since the tapestry was an obstruction to visitors and required the special attention of a security guard. In any case, it would have been impossible to work on the floor any longer, since the light was inadequate and the working position very awkward.

We found that both the wool and the silk of the tapestry are in a deplorable state. Over the entire tapestry the woollen thread in the weft has deteriorated and become so thin that it is now only half or less than half of its original diameter. The result is that the off-white threads of the warp show beneath it as minute light spots, which are distracting to the eye. There are also numerous areas where the woollen weft was replaced long ago; the irregularity of the mended holes suggests that they were caused by moths. While these repairs are technically correct, they do not match the original colour. The woollen warp is in relatively good condition, although here and there over the entire tapestry individual threads are broken.

The silk thread in the weft, too, has deteriorated. In fact, there are many areas where it is missing entirely, and only the woollen warp thread remains. Around these missing areas the silk thread has disintegrated

into small particles and shreds, which are holding together only because the tapestry is so compactly woven. Any mechanical abrasion will cause these threads to disintegrate completely. In all, about 30 per cent of the silk of the tapestry is missing, and what is left is in dangerously poor condition.

The worst spots are those in which the weft is missing and some warp threads are broken, so that the lower edge sags outwards. Where the weft is missing, loosened warp threads overhang in tufts, and the lining is visible through the gaps. The bottom of the tapestry is in much worse condition than the top, probably because it is within reach of visitors to the museum and has been handled frequently. Moreover, the tapestry is dirty, and this is particularly apparent on the beige silk weft, especially where it is broken and the ends are frayed.

Five strips of linen fabric placed equidistantly on the back of the tapestry, and a sheet of linen over the entire back were meant to secure the tapestry. Since they are attached only along the edges, they do not support the weight of the tapestry at all, but simply act as a dust barrier.

Except for the bottom section, the wide floral border of the tapestry is not original. The rewoven border has fewer warp threads per centimetre, and its colours do not match those of the original border, which are warmer and more saturated.

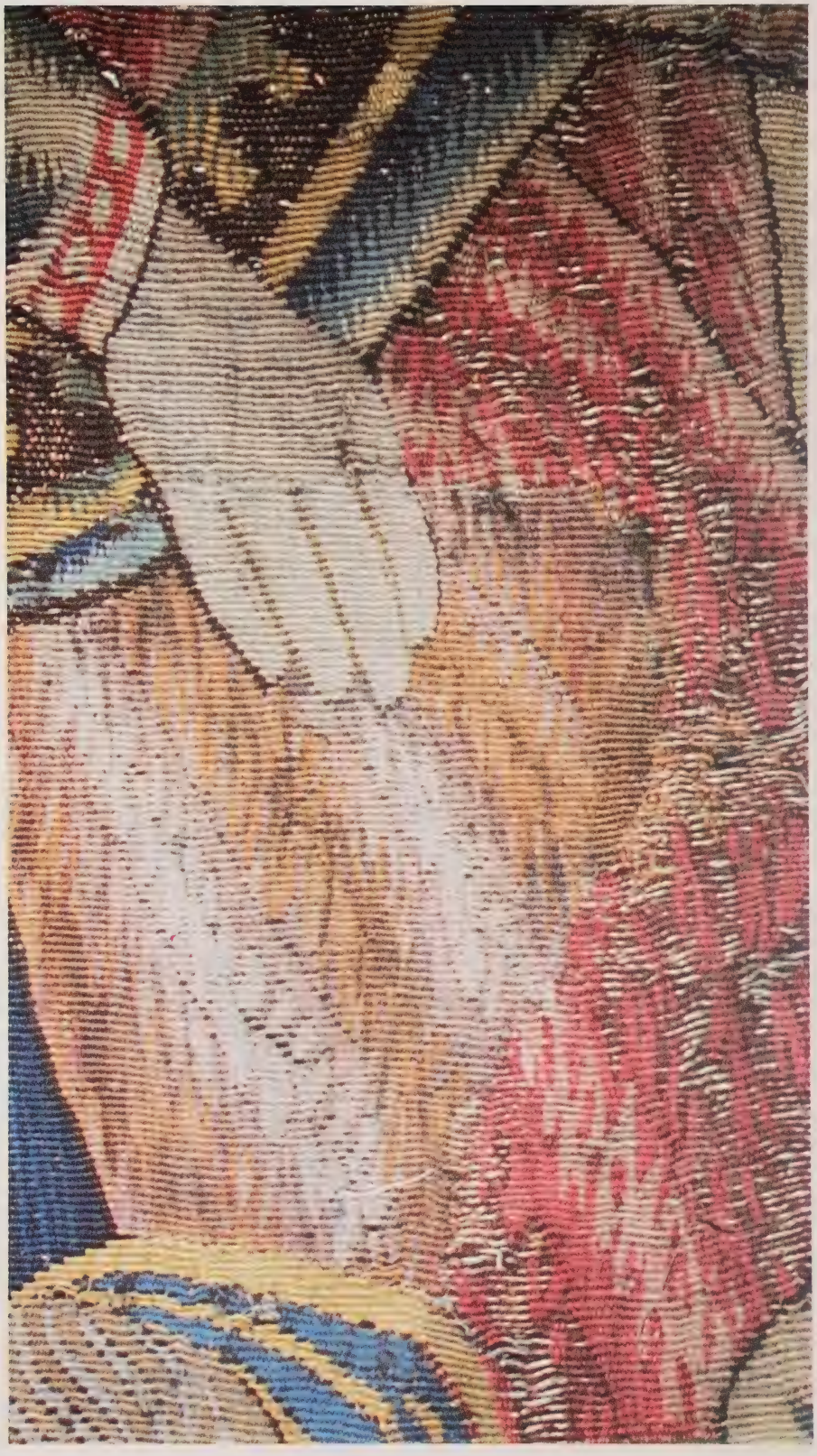
There had been repairs to the tapestry in the past—very harmful repairs, as it turned out. Damaged areas were fastened directly to the main lining, which is attached to the tapestry by a few careless rows of stitching and does not support it properly. Over the years the tapestry has stretched more and more, but the lining has not. As a result, the surface of the tapestry above the repaired areas does not cling to the lining but bulges out and forms a heavy fold that exerts strain on the damaged areas and encourages further deterioration.

Before the Flemish tapestry was removed from the wall of the Medieval Gallery, it was already clear that some first aid would be required. During the three days it remained on the floor of the Bishop White Gallery, the nails that attach the tapestry to the wooden bar on which it hangs were removed, and Velcro tape was substituted. The lining, which was pulling at the tapestry, was detached, and both sides of the tapestry were vacuumed. The old repairs were removed and reattached to new, locally applied patches, and the badly damaged and frayed areas at the bottom of the tapestry were secured.

This remedial treatment merely gave the tapestry a bit more lustre and colour, removed folds and wrinkles, and slightly improved its neglected appearance. This does not mean, however, that the tapestry is preserved. It is still hanging on a weft made of seriously deteriorated wool and badly rotted silk that do not give it adequate support, and the deterioration can only progress. To stop it, the tapestry would have to be submitted to thorough conservation treatment—the need for which has long been apparent. The remedy, however, is not as straightforward as it seems,

Opposite page: The repair of the tapestry was done on the floor. Here Charlotte Zuppinger of the Textiles Department is attaching weakened threads to a patch underneath.

Right: Original and rewoven areas in the tapestry and its border.



An example of a damaged area in the tapestry: a large proportion of the weft thread is missing.

for there are serious considerations involved. The exceptional artistic quality of the Flemish tapestry makes it one of the most important decorative art objects in the ROM. If it were taken off display for conservation, it would be expected back within a fairly short period, and that may well not be possible. Even after the tapestry is removed from the wall, conservation cannot be undertaken until a thorough condition report has been made. Only on the basis of such a report could the steps in conservation be planned, and then work could not begin on such a project unless there were funds available for it.

There are two approaches to the preservation of tapestries: *restoration*, which aims to secure all missing areas invisibly; and *conservation*, which aims to secure all missing and damaged areas, while leaving them visible. A third method, still in the experimental stage, would use synthetic resins as adhesives to glue the weak and damaged weft threads to the support, but would leave the usually healthy warp unglued and not involved in supporting the weight of the tapestry.

The restoration approach is tedious and time-consuming: it usually requires a team of qualified and experienced textile conservators and can take many years. For restoration work a conservation loom is necessary, on which the tapestry is rolled and then stretched to allow first the missing warp to be replaced and then the weft to be rewoven. Both wool and silk threads have to be dyed to match the original colours—a difficult task since the original colours are usually uncommon and often faded. Total restoration is extremely expensive, but sometimes it is the only method that will preserve the tapestry for a long period of time.

Conservation involves individual patching of the damaged and missing areas, which are stitched with cotton thread. Support is provided for the entire tapestry by an underlying fabric, whose strength is determined by the extent of deterioration and the weight of the tapestry itself. The support is sewn to the tapestry in rows of zigzag lines; the oblique stitching allows the tapestry to move on the thread without pulling and breaking it, and ensures that the weight of the tapestry is distributed evenly over the whole surface of the support. Conservation requires much less time than restoration, and less qualified people. Since the missing areas are not replaced but only secured to the lining with a cotton thread in a neutral shade, the burdensome task of dyeing threads can be avoided. No loom is necessary for conservation, as the tapestry can be rolled along the weft and placed on a large table. And conservation does prevent further deterioration for a relatively long period.

Decisions regarding treatment of the Flemish tapestry will be complicated. If the tapestry were to be restored, the obvious first step would be to remove the old repairs, as the colours do not match the originals and may bleed when the tapestry is washed. The border, on the other hand, is almost entirely rewoven, and the reweaving was probably done in the 18th century, so that it is now an essential part of the tapestry's history and should *not* be removed. Another problem is the silk weft, which is in such poor condition that the only remedy would seem to be to replace it. However, the areas woven with silk comprise more than 30 per cent of tapestry, and to remove that amount of thread would diminish the authenticity of the tapestry. It may well be preferable not to replace the silk but to repair it.

Before the Flemish tapestry can be treated, these and many other questions must be resolved, practical questions of space, time, and expense, and the ethical question regarding the extent of conservation — whether to strengthen the tapestry with new materials or maintain its historical integrity in a weaker state. One thing, however, is clear: this treasure should be preserved, and soon.

Izabella Block-Bolten was born in Poland and graduated from the Academy of Fine Arts in Cracow with an M.A. degree. Her work in textile conservation began in the Royal Castle in Cracow on the famous collection of 16th-century Flemish tapestries. She was also involved in the conservation of many other textiles at the National Museum in Warsaw and at the National Museet in Copenhagen. After receiving her B.A. in art history from the University of Toronto, she joined the ROM Conservation Department in 1974. One of her interesting experiences was a visit to Peru in connection with the exhibition "Gold for the Gods".

The Armour Court Project

Fine Weaponry

Chris Toogood

THE ARMOUR COURT is to me one of the most attractive areas of the museum. Not only is it frequently the focal point for very stimulating ROM gatherings (witness Romarama '78), but it houses a wonderful collection of arms and armour. To a former hunter who now prefers to shoot with a camera, weapons appeal now as art objects, displaying not only the craftsman's great artistic skill but also his practical mechanical inventiveness.

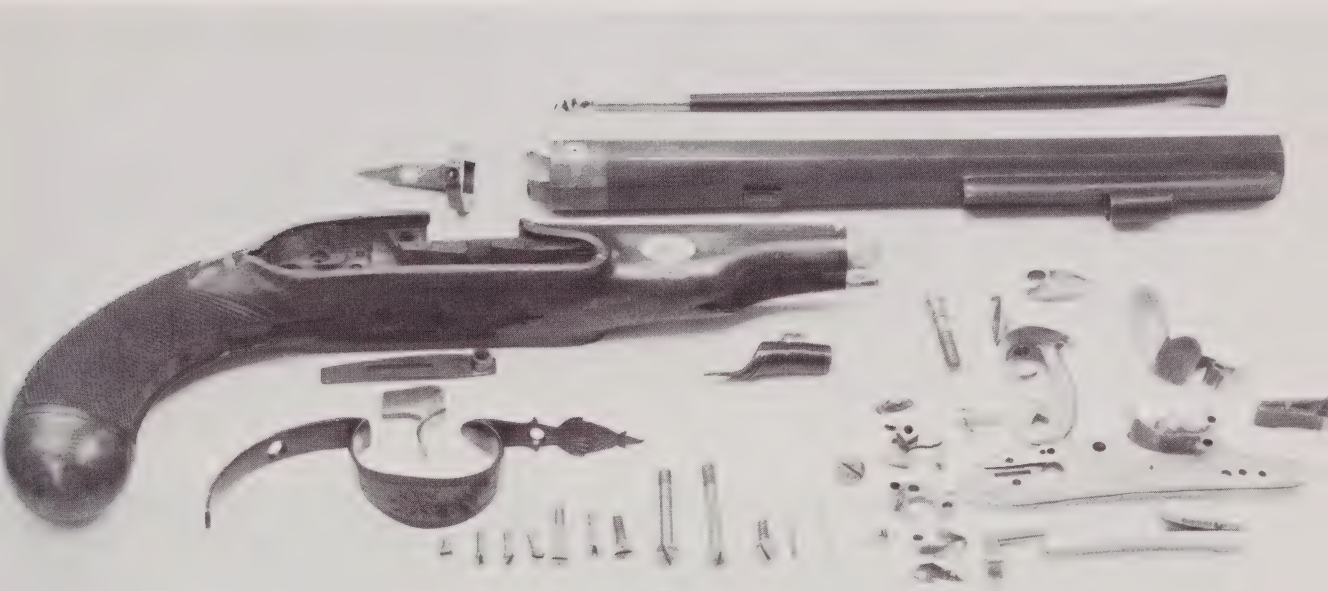
A pause in front of any of the display cases in the Court will give the viewer some idea of the numerous different crafts involved in the production of fine weapons. A closer look at artifacts like the double-barrelled shotguns by James Purdy of London will reveal the exquisite figuring in the metal of their seemingly plain brown barrels. This figuring was formed by hammering, and its subtle beauty is rivalled only by that of the magnificent Japanese sword blades displayed at the other end of the gallery. It is the quality of the craftsmanship in the arms and armour that I find so exciting and wish to help preserve for the inspiration of future generations.

In 1967 it was decided to line all the display cases in the Armour Court with V.P.I. paper. Vapour phase inhibitors were developed specifically to protect iron and steel surfaces from rust. V.P.I. acts by volatilizing; it reaches the metal surface in the vapour phase and adheres to it in the form of a normally invisible film which prevents corrosion by making the metal passive.

A decade later the metal objects in the cases lined with V.P.I. paper are fairly free of active corrosion, but there has been an unexpected side effect. Several years ago a white crystalline dust began to appear on the metal, and to an even greater extent on the leather and wooden objects also displayed in the cases. This crystalline deposit is not only unsightly but the volatilized V.P.I. has caused severe desiccation of the leather strapping that supports the armour. Other large museums that have used V.P.I. paper to line display cases have experienced the same phenomenon. The Conservation Department has now decided to remove all the V.P.I. paper from the cases and tackle the problem of conserving the arms and armour from another angle.

One of the major agents of destruction of museum artifacts is uncontrolled relative humidity, and thus it is imperative that each object be stored or displayed in the proper environment for the material of which it is made. But the vast majority of pieces displayed in the Armour Court are constructed of several different types of material, ideally requiring widely different levels of relative humidity. The 16th-century German crossbow, for example, has a steel bow and a steel trigger mechanism, which require a low relative humidity of 20 per cent, but the wooden stock, hemp string, and ivory and staghorn inlays require a high relative humidity of 50 to 55 per cent. Obviously a compromise has to be reached, and in the case of the crossbow an informed choice would be a relative humidity of 45 to 50 per cent —high enough to protect the organic materials and low enough to inhibit the growth of fungi. The internal and external metal parts would have to be protected (by oil, wax, or lacquer). Thin ivory and staghorn inlays, if the relative humidity were held reasonably steady, would remain stable and thus would require only a very light waxing.

One pressing factor in the conservation of the arms and armour collection at the ROM is the large number of objects involved: there are approximately 800 artifacts on display in the Armour Court, of which several hundred are firearms. For thorough treatment, each firearm must be completely dis-

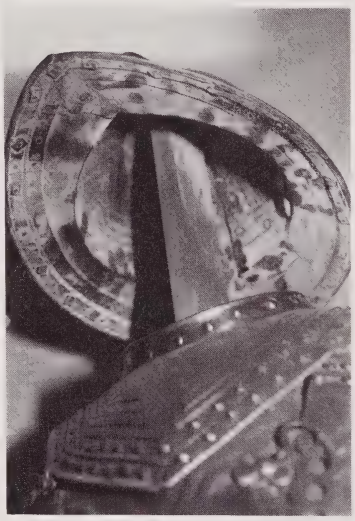


mantled into its 40 or 50 component parts, and every thread of every screw must be cleaned of any active corrosion. The suits of armour, on the other hand, cannot be completely dismantled, as their articulated parts are riveted together, making the areas between overlapping metal plates very awkward to clean. Then there are the acres of chain mail, some of it lacquered. Fortunately, if the artifacts are displayed and stored properly, the rate of deterioration is slow. Urgent jobs are done first and cosmetic treatments are left for some time in the future. The pressure of such a volume of work is greatly reduced through the help of a few excellent volunteers and interns, who do the more routine tasks of dusting and removing old lacquer.

One problem we are now correcting is the manner in which artifacts are supported in the cases. In the past many of them were held in place by bare steel brackets, which are unsightly and may cause scratches. We are now using Plexiglas, with much more pleasing results. Since some of the objects are very fragile, the designing of suitable supports for their display requires special care. The mount for one of the Viking swords, for example, was made by casting three supports for the blade in fibreglass and then mounting them on a Plexiglas base. This provides close support over a large surface area, so that the sword can be displayed either vertically or horizontally, and it can also be shipped safely to other museums.

Another practice of the past that is now causing problems is the old method of numbering weapons with metal identification tags attached by brass wire. In the humid environment of summer, the contact between steel and brass wire can start an electrolytic reaction, which may cause pitting of the steel. To eliminate this hazard, we are now attaching identification tags with nylon monofilament.

When handling weapons, my first concern is to ensure safety, for myself and others. The Japanese sword blades in the Armour Court will give



Top: English flintlock pistol, with its component parts.

Bottom: Steel helmet, showing the white bloom caused by the V.P.I. paper.

Right: A 17th-century Spanish Miquelet pistol of wood with brass overlay, during conservation. The metal parts have been removed and the pin holes in the handle plugged.

Below: The same pistol after conservation.

any double-edged razor a close run for sharpness, and a gun loaded 200 years ago will still fire. Thus I initially make sure that a firearm is not loaded and then I dismantle it, usually separating the uncoloured steel parts into two groups, according to size. The large pieces comprise the barrel, lock-plate, trigger-guard, butt-plate, and so on; the small ones include all the screws, pins, and lock parts. Rust is removed from the large parts electrochemically, and from the small ones electrolytically. In both processes a 20 per cent solution of sodium hydroxide (caustic soda) is used. A weaker solution would serve to reduce the rust, but the 20 per cent solution removes any protective lacquer or oil at the same time.

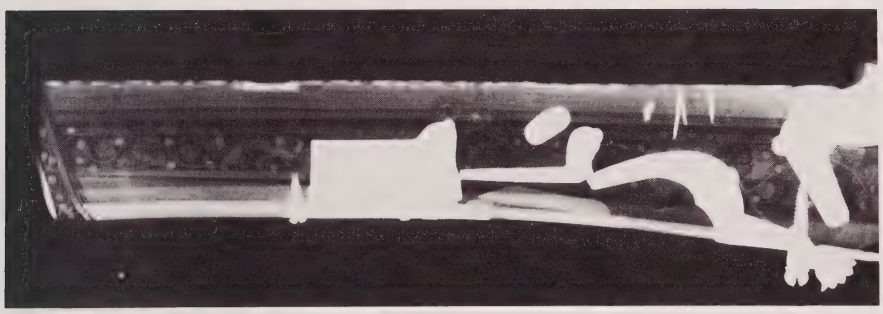
In both the electrochemical and the electrolytic processes, hydrogen is given off, which reduces the rust. For electrochemical reduction, the large uncoloured steel parts are placed on a zinc plate and immersed in sodium hydroxide. For electrolytic reduction, the small parts are placed in an iron basket, the basket is immersed in a sodium hydroxide bath, and an electrical current is passed through it to an iron anode. When this step is completed (in minutes or days, depending on the extent of the rust), the parts are scrubbed with very fine steel wool and placed in an ultrasonic cleaner. Once all traces of corrosion have been removed, the parts are washed in distilled water and dried in an oven. Then they are soaked in a mineral oil for at least 24 hours, wiped almost dry, and reassembled. Any highly polished parts are coated

with a mixture of microcrystalline wax and oil, as oil alone has a tendency to creep on a polished surface.

Obviously a suit of armour held together with leather straps that cannot be removed, or a blued gun barrel, or an artifact with a painted design or gilding cannot be immersed in sodium hydroxide. These require more time-consuming mechanical cleaning methods such as removal of rust with a chisel-pointed darning needle or a glass brush, local application of chemicals with a "Q-tip", or electrolytic sponging. Non-ferrous metals like silver and brass can simply be polished with a wadding polish, washed, dried, and lacquered to prevent further tarnishing. Wooden stocks are usually cleaned and polished with microcrystalline wax, after cracks have been repaired and missing inlays replaced.

Sometimes X-rays are useful for the examination of weapons prior to conservation. They show what sort of projectile is in a loaded gun. They reveal the internal construction of an unfamiliar weapon such as a crossbow, clarify the direction in which the metal axles and pins in its stock should be punched out, and reveal tips of screws embedded in the stock (screws that must be removed, for in time, as they corrode, they will expand and possibly crack the wood).

This article has given the reader some idea of the tasks involved in the conservation of arms and armour in the collections of the ROM. Many years of painstaking work will be required but they will be justified by the pleasure the display gives to the hundreds of people who daily visit the Armour Court.



Above: Detail of the barrel of a 19th-century German duelling pistol—a very fine example of gold and silver inlay.

Left: X-ray elevation of a part of the stock of a 16th-century German crossbow, showing the internal metal mechanisms. Note the broken screw tip.

Chris Toogood, a trained silversmith, specializes in the conservation of bright metals and arms and armour. A native of Belfast, Northern Ireland, he was educated at the Ulster College of Art and Design and the Central School of Arts and Crafts in London, England. He has been with the Conservation Department of the ROM for four years.

The Ming Tomb

Causes of Deterioration in Stone

George Pawlick

TWO COLOSSAL BUDDHIST guardian lions are poised protectively at the first gate of the Ming tomb in the Chinese Garden of the ROM, but they are powerless against the forces of a hostile environment. The monuments are black with grime, their stone is marred by degeneration, and the green glazed tiles over the gateways have lost their lustre.

The tomb is that of General Tsu, and it was originally built at Yung Tai Chuang, Chihli, in the 16th to 17th century A.D. during the Ming Dynasty. In 1918 George Crofts acquired for the ROM the tomb, two gateways, each with variously decorated relief plaques on all four sides, two large standing figures of officials, and two reclining camels, all of which formed part of the traditional "Spirit Path" or avenue of approach to the tumulus (grave mound). The tumulus, too, is installed in the Chinese Garden.

The two lions, or Dogs of Fu (Buddha), came to the museum in 1923 and are not actually part of the tomb. They once stood in front of the palace of Prince Su in Peking and are believed to be of late Ming or early Ch'ing date (17th century A.D.). The male rests his right front paw on the familiar ball of brocade, and the female has a cub under her left front paw.

General Tsu's was the typical tomb of a rich man in the Ming Dynasty. In the family cemetery of about 10 acres, it was the central and largest tomb; six smaller ones contained

The "Spirit Path" at the original site after the land was placed under cultivation. The ROM's camels are in the mid-ground.

the bodies of members of the general's family and his soldier-servant. The grave chamber, 8 feet high and 10 feet square, was constructed underground with a mound of earth above it, which was enclosed by eight carved marble plaques depicting the Immortals arriving to pay homage to Lao-tzu, founder of Taoism. Behind the tomb was erected a semi-circular granite wall 20 feet high, 12 feet wide, and 300 feet long. In front of the tomb at a distance of 450 feet stood one of the gates, and at the same distance beyond it stood the other. Six of the carved marble plaques on the gates portray the kylin, a fabulous animal symbolic of peace and happiness, whose function was to protect the tomb from unseen evil influences.

Extending from the second gate to the cemetery entrance, a distance of nearly half a mile, was an avenue formed of facing pairs of stone figures: two military officers, two civil officials, two camels, two horses, and pairs of other animals. These, too, were present to protect the soul from harm. No doubt their use had evolved from the earlier practice of burying live animals, and people, with the rich and royal dead to ensure safety and service.

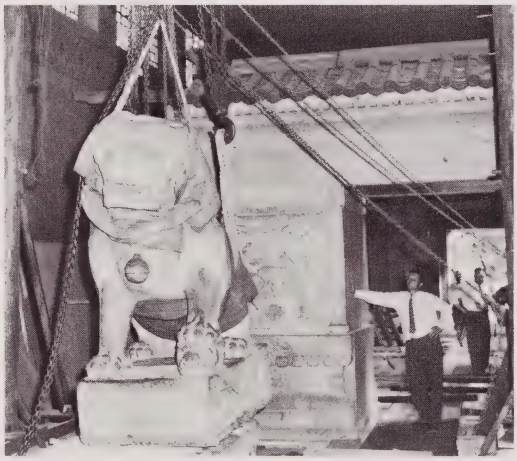
When the museum acquired the Ming tomb, General Tsu's cemetery grounds were being placed under cultivation. The six smaller tombs had already been levelled, the majority of the stone figures had been removed or destroyed, and General Tsu's grave chamber had been broken open and looted. Nothing remained in the chamber but a small stone altar, on which there had probably been a bronze or pottery "sacrificial set of five", comprising an incense urn, a pair of pricket candlesticks, and a pair of flower vases.

To house the Ming tomb, the ROM built a new wing in the 1930s. Then in 1959, when the wing was renovated to serve as Exhibition Hall, the tomb group was moved out of doors and set up in the Chinese Garden. The transfer took several months and required the combined skills of conservators, engineers, movers, and heavy equipment specialists.

When the tomb group was moved outside, the very important facts of the behaviour of stone in our environment were not seriously considered. An increase in industry and the burning of fossil fuels has, over the past century, caused a severe rise in atmospheric pollution in urban and industrial areas. Just two years after the tomb group was moved outside, it became apparent that the location and climate were most unsuitable for the stone. In dealing with sedimentary and metamorphic rocks one has to remember that they are soft, porous, and vulnerable to atmospheric pollution. Frequent inspections of the figures and the gateways revealed progressive deterioration — caused by physical, chemical, and biological attacks.

Two of the most damaging contaminants are sulphur dioxide and sulphur trioxide. In the presence of water or water vapour these form sulphurous and sulphuric acid, both of which will attack the calcium carbonate in calcareous materials such as these limestones and marbles. The calcium sulphate formed is slightly soluble in water, but the acidic nature of polluted city rainwater increases its solubility. Thus calcium sulphate that forms on surfaces exposed to weather will be washed away by rain, leaving an eroded surface.

Colossal lions being transported from Prince Su's palace in Peking to the shipping point.



This Dog of Fu from the Ming tomb weighs 12 tons. Here it is being moved from the gallery to be installed in the garden, 1959.

The Chinese Garden in winter.

On surfaces that are protected from the weather a hard crust of calcium sulphate, which traps dirt and disfigures the stone, is formed. This crust is less permeable than the stone, and so moisture that was free to evaporate from the surface of the stone becomes trapped behind the crust. This causes gradual deterioration of the binding material of the stone, with the result that the surface under the crust becomes powdery. Changes in temperature cause the crust to exfoliate because of the difference in expansion and contraction rates, exposing the surface of the stone to more deterioration.

In excessive amounts, carbon dioxide, a natural constituent of the atmosphere, is also harmful to stone. Combined with water, it forms a weak carbonic acid that will attack and dissolve calcium carbonate. Soot contains unburnt tarry particles that enable it to adhere to stone and accumulate. Since soot is hygroscopic, it promotes deterioration and at the same time discolours the surface of the stone. Airborne dust, too, soils the stone, and it has a chemical effect as well, since the dust particles have absorbed dilute acids and soluble salts.

The rise of moisture by capillary action exposes the unprotected monuments to ground moisture and sometimes to salt impregnation, which is a relatively slow but cumulative process. The salt may come from the ground, or it may be transported by driving rain from the city sidewalks and roads on which it has been sprinkled. The weathering of iron minerals in

Above: Surface etching by sulphuric acid released from oxidized sulphides.

Right: Rusty encrustations on the marble relief, products of the weathering of iron minerals.

Opposite page, left: A view of one of the eight marble plaques from the tomb before assembly in the gallery.

Opposite page, right: The same plaque 10 years after it was moved outdoors. Note loss of details on the relief surface and visible evidence of stone decay.

marble is another action that is harmful to the stone. The process of oxidation and hydration forms nearly insoluble oxides and hydroxides of iron, which show up as ugly brown spots or rusty stains.

Winter freezing and frost cause the stone to split and crack, and summer humidity contributes to considerable biological activity. Fungi and mosses appear constantly in the seams and cracks of the tomb itself, where moisture is supplied continuously by condensation in its interior. Because they retain water, they also contribute to stone decay.

For years the ROM's incinerator emitted soot into the air. This, combined with pollutants from heavy automobile traffic, settled on the stone and blackened the monuments. When the new cafeteria was built, the open balcony and the patio attracted many birds. The population of pigeons and sparrows in the garden doubled, and now their excrement covers the monuments. To end the list of factors contributing to the decay of the stone, one has to mention the damage done by the children who climb on the monuments, and the squirrels that scamper over them, leaving abrasion marks in the stone.

In the past few years serious efforts have been made to prevent, or at least delay, the disintegration of the stone through cleaning and waterproofing, but they are not enough. Fortunately, the expansion of the ROM will provide a sheltered gallery for the Ming tomb, where it will be protected from the ravages of the weather, and so can be admired for years to come.

George Pawlick joined the ROM in 1963 and worked for the Earth Sciences Department, where he gained a thorough knowledge of minerals, their occurrence and their behaviour. His interest in archaeology led him to the Office of the Chief Archaeologist, where he restored material from the Maya site in Belize. A few years later he joined the staff of the Conservation Department and is now engaged in the conservation of ceramics and stone and glass objects. On numerous trips abroad Mr. Pawlick has visited the British Museum and the Victoria and Albert Museum to familiarize himself with new methods and materials being used in conservation.

An Un-Restoration Project

Conserving a Lacquered Wooden Cabinet

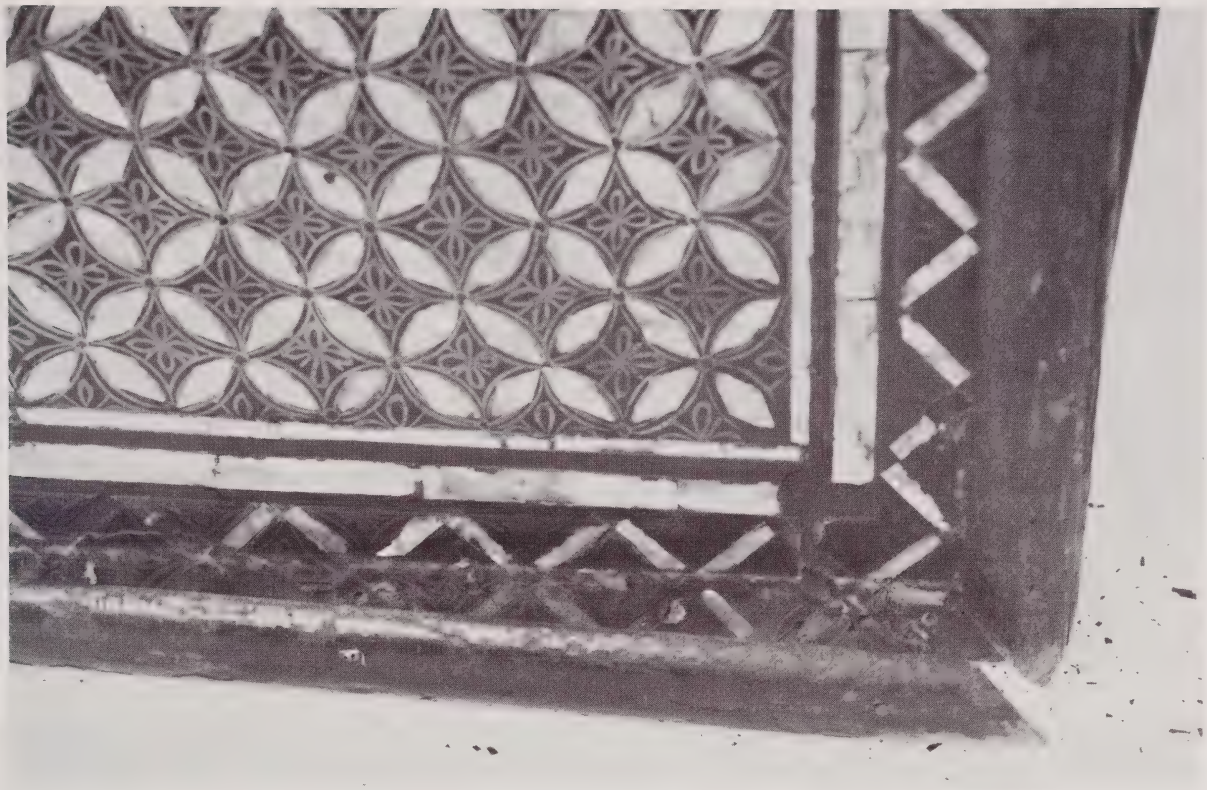
Gillian Moir

THIS IS THE STORY, still unfolding, of a ROM artifact. Unlike many objects that come to the Conservation Department, this one had already been "restored", and so it became the conservator's job to deal not only with the original damage and deterioration but also with the results of past attempts to protect and repair.

The artifact in question is a black lacquered wooden cabinet about 40 cm deep × 75 cm wide × 53 cm high, with a drop-front door, behind which there are 12 drawers. The surface is covered with foliage and geometric designs in gold and red lacquer, with side and door panels of animal scenes. These decorations are enhanced by mother-of-pearl inlay with the green/purple iridescence of abalone shell.

The cabinet is of Japanese manufacture, after a Portuguese design. Many such pieces were produced in the Far East during the 17th century for the European export trade, and this one found its way to England. While the workmanship is not of the highest quality, the lacquer decoration is beautiful. Unfortunately, it is also very thin and thus difficult to preserve.

Lacquered wooden artifacts can be a conservator's nightmare. Wood is a hygroscopic material, that is, it readily



absorbs moisture from the air and expands and contracts with changes in relative humidity. Lacquer, however, does not: it is a hard substance derived from tree resins and tends to become brittle and fragile. Consequently, when the wood core of an object moves even slightly, the lacquer covering may form tentlike ridges, or simply crack and flake off. Lacquer has the added disadvantage of being very vulnerable to damage by heat, including the heat generated by strong light.

When this lacquer cabinet came to the department, it showed the effects of years of poor environment, thoughtless handling, and insensitive restoration. Shrinkage in the door, the fragility of the lacquer, and a wide split through one side panel indicated that the cabinet had endured conditions that were too dry. The lacquer was flaking badly, especially on the lower part of the door where the central wood panel had shrunk and pulled the lower frame into a bow, loosening the hinges in the process. Many other areas were buckled and cracked. The side panels and the door had lost their original gloss through the development of a fine network of tiny "alligator" cracks, possibly because of exposure to hot sunlight, although harsh cleaning methods may have been responsible.

Many pieces of mother-of-pearl had flaked off, but luckily some had been retrieved and placed in a drawer. The diagonal metal plates that originally protected the corners of the cabinet were missing (gaps in the lacquer design indicate where they had been). Mishandling was evident in scratches and gouges on the animal scenes, probably caused by careless moving. More serious damage had occurred around the lock-plate of the

Opposite page: The cabinet with the front door removed. The front edges had been planed down before the moulding was added, resulting in a bare wood surface. The lower left drawer has not been cleaned and retains its Victorian knob.

Above: Detail of a corner of the cabinet door, with the half-round moulding partially removed, showing the inlaid design underneath. Note also the flakes of lacquer which have fallen from the cabinet. The varnish has not yet been removed.

door and around the side handles, where harsh polishing had abraded the lacquer so severely that the surface was worn away — right down to the wood in some places. The metal fittings, probably gilded at one time, were merely copper-coloured, and the ornately engraved lock-plate had been polished almost smooth.

Earlier efforts to protect the cabinet and restore its beauty had spoiled its appearance. Sometime in the past half-round moulding was nailed around the edges of the sides, top, and door, possibly in an attempt to disguise flaking losses. The moulding obliterated the clean lines of the cabinet and further marred the surface with nail holes and rust. At some time, too, the top of the cabinet must have been severely damaged, for it was covered with a canvas on which had been painted a red, blue, and gold chinoiserie design typical of the mid-18th century. The design was so darkened that it had almost disappeared, and both the canvas and paint surfaces were very brittle.

The entire cabinet had been given a heavy coat of varnish, grown so dark and yellow through exposure to light that the decoration beneath it was barely visible. Previous attempts to scrape the varnish from mother-of-pearl leaves on the back had resulted in deep scratches to the inlay and loss of the gold lacquer leaf veins. Fortunately, the sides and front had not suffered this attention. Some areas of inlay loss had been crudely filled with white mother-of-pearl strips. Lacquer losses had been replaced with gesso painted black, on which a design had been executed in bronze powder "gold" paint that had darkened with time. Moreover, the design was different from the original in style and pattern.

Modifications to the hardware had altered the character of the cabinet. The original fittings were probably stylized metal lotus flowers with pull-rings, but they had been replaced by wooden drawer knobs with mother-of-pearl inlay, very likely in the 19th century. The wooden knobs were roughly attached with overlong screws, and the large one on the centre drawer was attached through the keyhole with an enormous bolt. Two small locks were added to the door by chopping away the decorated surface on the inside; the intials VR indicate that they too are Victorian additions.

Conservation of the cabinet involved two principal concerns: how to prevent further deterioration, and which of the restorations to preserve and which to

remove. The answer to the first is straightforward in theory — keep the cabinet in a constant environment of high relative humidity (at least 60 per cent) and protect it from heat and light. These are demanding requirements and will have to be faced when the piece is ready for display.

The second concern presented a more immediate challenge. It was first decided that the half-round moulding and discoloured varnish should be removed. At the same time the old overpaints could be removed, as they were soluble in the same liquid. The results were spectacular — the gold, red, and mother-of-pearl were restored to their original lustre, and on the drawer fronts and back the lacquer had retained its glossy sheen. Most of the geometric inlay design remained under the mouldings, and the cabinet now had a more unified appearance.

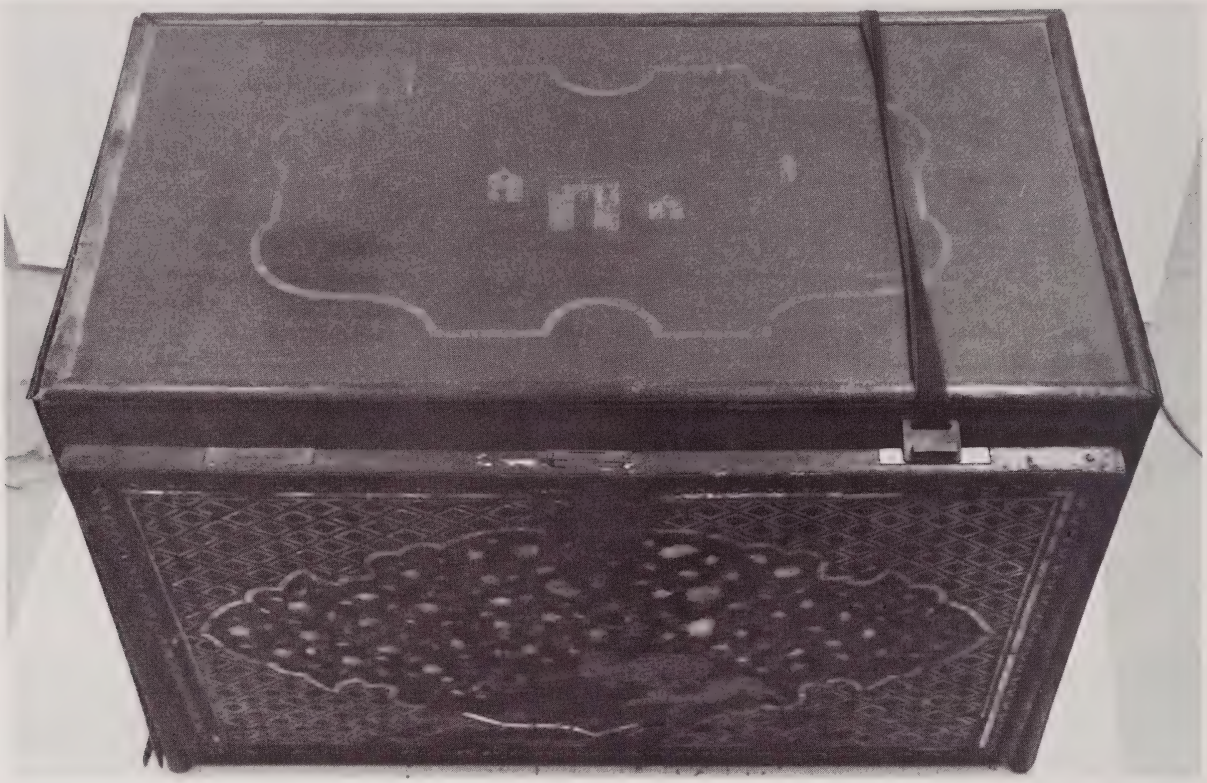
When a corner of the canvas on the top of the cabinet was lifted, an inlaid design was revealed beneath it. It was then decided that the canvas should be removed and conserved to strengthen it. If the top surface of the cabinet is too badly damaged to be of museological value, the treated painted canvas will be reattached. If the top surface can be saved, the painted canvas will be mounted for display with the cabinet as a separate historic artifact. The Victorian locks and knobs will probably be kept, since the damage to the cabinet has already been done and the original drawer-pulls were probably lost long ago. Indeed, in another hundred years or so, the Victorian additions will have their own historical value.

A great deal of work remains to be done on the cabinet before it is ready for public display. The lacquer will have to be consolidated and strengthened, and losses will have to be filled in to restore the continuity of the design. These fills will be done with materials easily distinguishable from the originals. For example, the mother-of-pearl will be replaced with thin strips of plastic coated with pearlescent nail polish in various colours. Conservators would not seek to restore an artifact to its absolute original state, even it were possible to do so, because damage and changes are part of the history of the artifact. Thus "restorations" use materials that at normal public viewing distance match the originals but on close investigation reveal that conservation has been done. Moreover, the materials used must be easily removable in case a conservator in the future wishes to apply improved methods or a curator decides the piece would be more useful unrestored. A conser-

Opposite page: The back of the cabinet, half-cleaned of varnish. The inlay along the lower edge has been lost.

Right: Detail of the lock-plate of the door. Note the abrasion and loss of design from harsh polishing methods. The engraved design on the plate is very worn.

View from above the cabinet before treatment, showing the painted canvas applied to the top.



vator tries to be true to the original artist's intention, without falsifying the history of an artifact.

It may be years before the treatment of the lacquered wooden cabinet is completed, since it must be fitted into the regular heavy workload of the department and proceeds intermittently. This is a long-term project and a complicated one, made up of many tasks requiring inventive solutions. The results should be gratifying to conservator, curator, and museum visitor, and perhaps even to the spirit of the original artist. When this magnificent piece is finally displayed in the galleries in all its renewed beauty, the consensus is bound to be that time and effort were well spent.

Gillian Moir is conservator of decorative arts. She received a B.A. (Honours) in medieval and renaissance history from the University of Manitoba in 1972 and her Master of Museology degree from the University of Toronto in 1974. She began work with the Conservation Department as an intern in 1973, specializing in metals and ethnographics. Her previous occupations have included structural drafting and a historical survey of Manitoba architecture, which involved writing the book Early Buildings of Manitoba.

The Growing Collections

Gifts of glass still continue to come in as a result of "A Gather of Glass", our special exhibition last fall. The most noteworthy recent acquisition in the European Department is a large cameo glass vase by the Emile Gallé factory in Nancy, France. Emile Gallé (1846–1904) was largely responsible for developing the naturalistic manner of plant decoration for glass and furniture in what is known as the Art Nouveau style. Although he began by designing ceramics, by the 1870s he was involved with glass. In 1889, to offset the costs of his small production of luxury wares, he launched a commercial line of quality cameo glass. This was glass built up while hot in multiple layers. When it was cool, the designs were painted on with pitch or wax and the surrounding area was eaten away by hydrofluoric acid. Our new vase is further enhanced by having the pale mauve plums blown in relief and a chemical stain of amber yellow painted on the inside. This appears very attractive in the proper light. On the best Gallé vases, the cameo reliefs were cut entirely by hand with a cutting wheel. None of the examples in the ROM collection is of this rare first quality; however, this plums vase with its rich maroon cameo is an extremely desirable and large example (13 inches tall) of the commercial line about 1910.

Gallé was the first glassmaker to sign his glass as a regular practice. The idea was that each piece was an individual artistic creation. This vase bears the Gallé signature in cameo relief and is additionally interesting since the notation MADE IN FRANCE is etched on the bottom. This indicates that the piece was made for export to an English-speaking country.

We owe a special thanks to Sol and Anne Atlin for generously donating this fine example to our collection and to Mrs. Esther Goldstein, a museum member, for putting the Atlins in contact with the European Department.

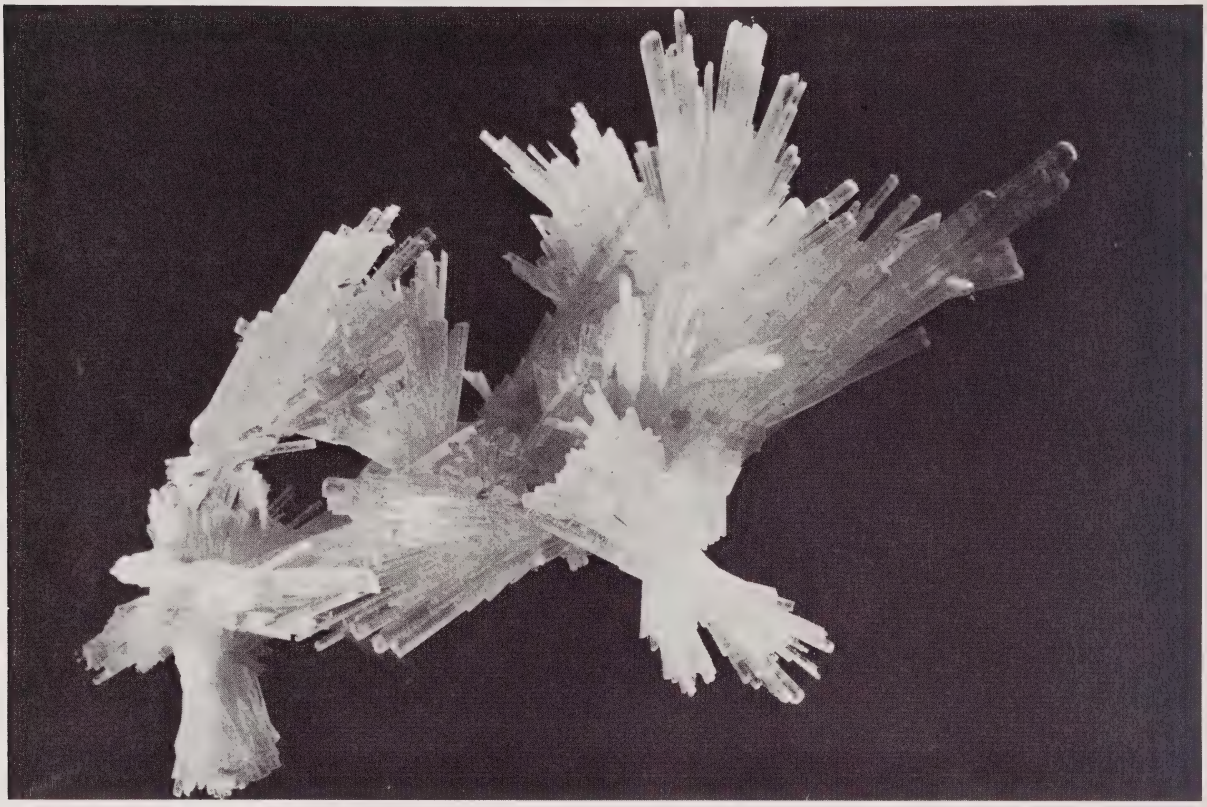
C.P.K.

The Islamic world inherited the advanced technology of glass manufacture from their Roman predecessors and carried it even further. Related to glass, but a non-manufactured product, was rock crystal, a natural, semi-precious, transparent stone (quartz), whose value far exceeded that of glass because of its rarity and brilliance. Most of the Islamic objects and vessels of rock crystal come from Fatimid Egypt (10th to 11th century A.D.) and were made for the ruling family. The West Asian Department has acquired a very small rock crystal basket with bevelled carving and two pierced lugs through which a string would have been drawn to suspend the little basket from something else.

L.G.

The Ontario Ministry of Natural Resources, Algonquin Region, recently donated a collection of 130 marten and 57 fisher pelts to the Mammalogy Department. The material was obtained from local trappers by C. W. Douglas, the Ministry's Regional Biologist, as part of a detailed study of the biology and population dynamics of these two species of fur bearers. This collection is documented with considerable biological data. In addition to pelts, there are corresponding skulls, reproductive data, and age data for many specimens. With this acquisition, the Mammalogy Department now has one of the largest scientific collections of marten and fisher specimens in North America.
D.N.

Hand-turned bowl, of burl butternut, Western Ontario, c. 1830. This especially excellent early Upper Canadian piece was purchased through the Donald MacLeod Memorial Fund, formed from donations by Donald MacLeod's friends within the museum. It was presented to the Canadiana Department on May 3, 1978.
D.B.W.



Twenty-two species not previously registered in the ROM collections were acquired by the Department of Mineralogy and Geology during the past few months. Although some of these are "old species", the majority are new minerals that have only recently been approved by the International Commission on New Minerals and Mineral Names. Most were gained through purchase, some by exchange, and a few were received as gifts. As always, we are very grateful to our kind donors.

Other specimens of note that have been acquired recently include a very fine green grossular from Asbestos, Quebec, a superb group of hureaulite crystals from Brazil, and a fascinating study collection of 13 rhodochrosite specimens from South Africa, all showing different features. An attractive manganite from Atikokan, Ontario, was received on an exchange from the National Museum of Natural Sciences in Ottawa. A few beautiful and delicate groups of pectolite (illustrated) from Asbestos were purchased, as well as a collection of 20 excellent micromounts of minerals from Mont St. Hilaire, Quebec. Also of interest was the acquisition of a few specimens from the famous Lazard Cahn collection. A fine example of howlite crystals from Cape Breton Island was donated by Dr. Peter von Bitter of Toronto.

R.I.G.

During the early part of the year the Ethnology Department had the good fortune to participate in a field project with the Museo Nacional de Antropología y Historia among the Nahua and Huastec peoples in the Mexican state of Vera Cruz. The resulting collections and documentation typify the many aspects of these cultures – notably the technical processes of manufacture of articles important to local economy and daily life. Included are woven sisal bags, braided palm-leaf sombreros, sisal ropes, and ceramic vessels. This material represents the entire holdings from these cultures in the collections of the Ethnology Department.

In addition, during the same period independent field work in the State of Oaxaca resulted in a collection of clothing and ceramic vessels.

A.B.

Cherish the Patina

Bronze and Bronze Disease

Carol J. Jack

MANY ROM CURATORIAL DEPARTMENTS with archaeological collections have in their custody large numbers of ancient bronze artifacts, and one of their vital concerns is "bronze disease". While the percentage of objects visibly exhibiting this condition may be relatively small, the total number affected may turn out to be much higher.

Once discovered, serious cases of bronze disease have priority and receive first aid immediately. For example, the bronze cosmetic bottle that was part of the Conservation display case in the Museum subway station illustrates an advanced case of bronze disease, a very disfiguring patch of light green powder at the neck. The bottle is kept in a sealed container with silica gel desiccant, one method of providing a stable dry environment.

Only a fraction of the ROM archaeological bronzes have been examined and treated. Most of these arrived in the Conservation Department for quite different reasons: an old repair gave way or they were brought for examination prior to display or loan. During the past five years more than 400 Chinese bronze weapons, which form part of a research project, have been brought to the department for spectrographic analysis. Whatever the reason for an object's sojourn in the department, it is examined and appropriate steps are taken to treat any bronze disease present. The Conservation Department has now developed a long-range plan for examining and treating all the ancient bronzes in the ROM — a formidable undertaking from the standpoint of both time and manpower.

We are often asked "What is bronze disease and how can it be treated?" To answer this question we must first consider the nature of bronze. Metallurgically speaking, bronze is an alloy of copper and tin, which was known to man more than 5,000 years ago. Although the earliest bronze was probably produced accidentally, as early as 3000 B.C. the alloy bronze was being made by adding tin oxide to copper. Copper in its natural state is soft and malleable and would not have been a satisfactory substitute for flint in arrowheads and spearheads. The addition of tin to the copper formed a harder alloy more suitable for use in arrowheads, spearheads, axes, daggers, cannon, and statuary.

The alloy had other advantages as well: it made available a wider range of colours, from pink to orange to yellow to silver, and, depending on the proportion of tin added, had a melting point considerably lower than copper. Moreover, copper is a poor metal for casting as the melt is sluggish and viscous; it shrinks on cooling, thus not filling the mould, and tends to be porous. The addition of tin to the copper increases the liquidity of the melt, allowing the alloy to fill the details of the mould more exactly. Lead was, and frequently still is, added to the copper-tin alloy to make it easier to pour and heavier.

The copper, tin, and lead ores from which the metals were derived contained trace elements — slight amounts of arsenic, antimony, iron, nickel, silver, and zinc. In ancient times arsenic was sometimes added to copper to produce a harder bronze. (Repetition of the process may also have shortened the life of the metallurgist.) Unfortunately, the arsenic made the bronze brittle, and so arsenical bronze is usually found in objects such as daggers intended only for ceremonial use.

Zinc is sometimes present in ancient bronze, most likely having been included in the form of an impurity in the copper. It was not added deliberately until much later, and then in ore form, since zinc

Above: This cosmetic jar from Iran has extensive areas of bronze disease. It has been sealed into a Plexiglas container with silica gel to maintain a dry environment.

Opposite page: This jue shows a characteristic patina. Spots of bronze disease are visible on the inside.

as a metal element was not isolated until 1746. Bronzes with some zinc in their makeup have a lighter yellow colour; if the alloy contains more zinc than tin, it is called brass. Modern brasses, however, seldom contain any tin at all, and they range in colour from reddish to yellow, according to the proportion of copper to zinc.

Two modern bronzes bear mention. One is "aluminum bronze" which contains 10 per cent aluminum alloyed with copper, and no tin. The second is "phosphor bronze" which can have different compositions to fulfil different needs. The tin content of the "phosphor bronze" varies from 1.25 to 10 per cent, with usually no more than 0.35 per cent phosphorus. However, that little bit of phosphorus produces an alloy with great resilience, hardness, and fatigue endurance, as well as greater resistance to corrosion.

It is often said that the moment he is born man begins to die. So it is with bronzes, which have a tendency to revert to the ores and minerals from which the alloy was made: green malachite and blue azurite (basic copper carbonates), purple or orange cuprite (copper oxide), and cassiterite (white tin oxide). Thus as soon as the bronze object is cast it begins to tarnish — the first step in mineralization.

Several environmental factors influence the variety of corrosion products found on ancient bronzes. Was the object buried? If so, what kinds of salts were in the soil? Was the soil dry or wet? If not buried, was the object kept in a dry, temperate, or humid atmosphere? Was it near salt water? And so on . . .

When a bronze is buried, especially in damp soil, or in alternate damp/dry cycles, the process of corrosion is inevitable. If there are chlorides in the soil, a layer of cuprous chloride forms next to the metal; then a layer of cuprite develops; and surrounding all that there may be a layer of green malachite, and possibly the rarer blue azurite.

Corrosion is a complicated process. There may be redeposited copper in the cuprite layer, cuprous chloride may get mixed up with the copper carbonate, and the tin may leach out of the copper to the surface to form a beautiful green-grey patina of tin oxide (the green colour is imparted to the white tin oxide by copper salts).

While the bronze object remains buried, it reaches a state of equilibrium with its environment. Once dug up and exposed to a different environment, however, that equilibrium will be disturbed. As long as layers of copper oxide and/or copper carbonate protect the layer of cuprous chloride lying next to the metal, the cuprous chloride remains stable. If the protective layers are chipped, cracked, or scraped, allowing

A bronze lion pin from Iran, before and after electrolytic reduction was used to remove heavy corrosion deposits.

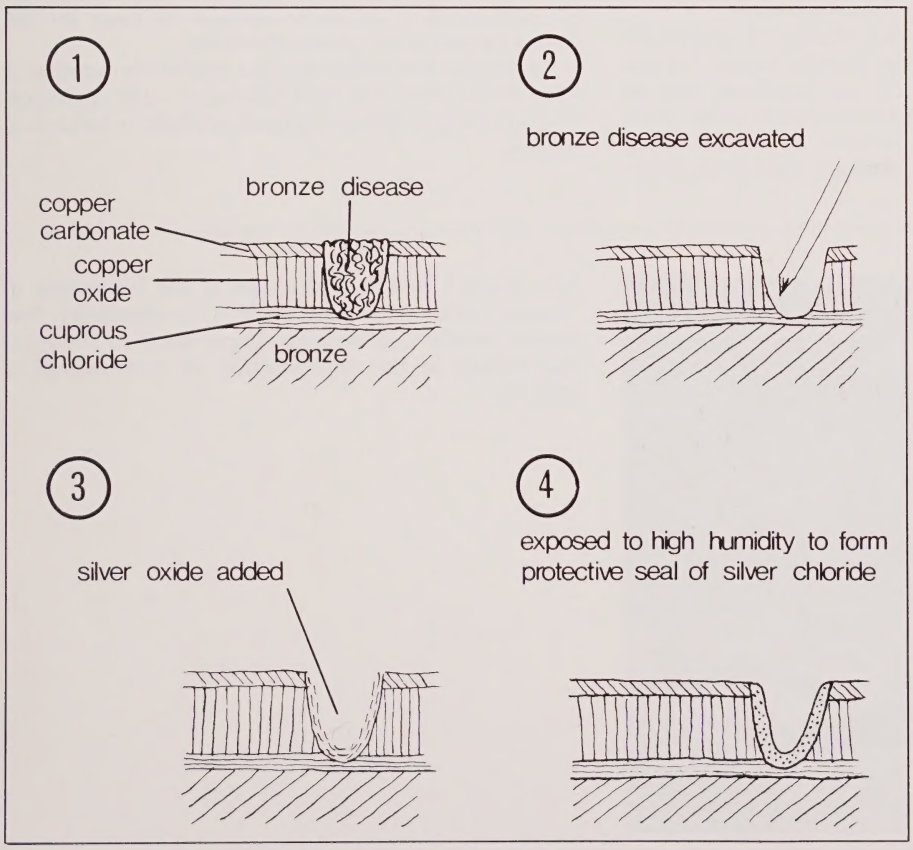
damp air to reach it, changes take place. The cuprous chloride is oxidized as well as hydrated, and it swells to become green cupric chloride dihydrate (the minerals atacamite and paratacamite). This dries out to become the light green, powdery spots known as "bronze disease", and the corrosion will continue until no metal remains. It is the purpose of the conservator to slow down, if not reverse, the natural corrosion process.

For bronze disease to develop, three things are necessary: the presence of chloride, oxygen, and moisture. Thus the obvious method of controlling the disease would seem to be to keep corroded bronzes in an atmosphere of low relative humidity, about 20 per cent. This solution is less simple than it seems in a museum with collections of ancient bronzes numbering in the thousands and a building without environmental control, in a climate where the relative humidity in summer hovers between 50 and 100 per cent. The best we can do at present is to keep a few bronzes dry in micro-climates using silica gel, but the renovation and expansion programme of the ROM will improve this situation considerably.

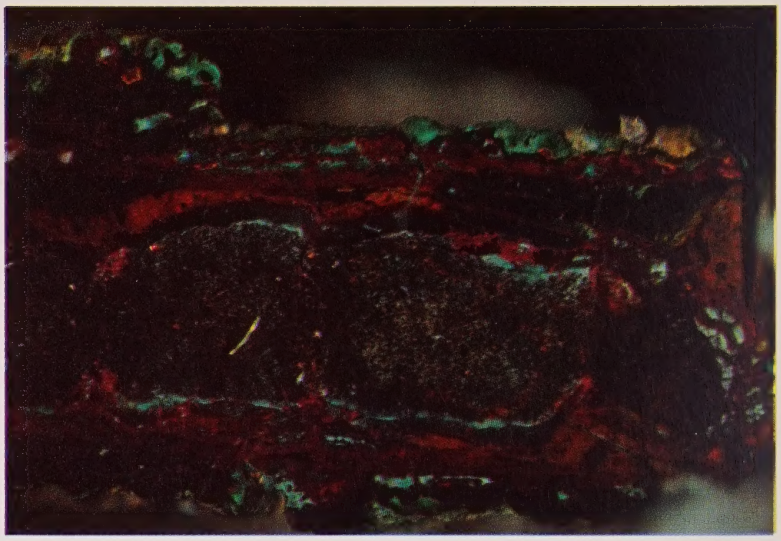
If there are only a few spots of bronze disease on an artifact, they can be dealt with locally. The light green spots of cupric chloride are first excavated with a chisel-shaped needle to expose the waxy layer of cuprous chloride under them (care must be taken not to allow the powder to fall on healthy patina). A paste of pure silver oxide in alcohol is then applied to the exposed layer, and the artifact is subjected to an atmosphere of 80 per cent relative humidity for 24 hours. Under these conditions the cuprous chloride will react with the silver oxide to form cuprous oxide and silver chloride, stable salts that seal off the cuprous chloride from further attack by moisture.

It is usually considered desirable to preserve the patina on ancient bronzes. Occasionally, however, an archaeologist will bring into the Conservation Department a bronze object that has massive corrosion covering the original detail, which the archaeologist wishes to study. It is possible to reduce this corrosion electrolytically by use of a stainless steel anode and sodium hydroxide electrolyte: the object becomes the cathode, and direct current is applied. The hydrogen ions migrating to the object turn the mineral back to metal, and the light sludge formed over the original surface can be brushed off. This process also effectively removes all chlorides.

The most recent method of treating bronze disease was developed in the course of industrial research. It was found that treating copper signs and roofs with the chemical benzotriazole made them resistant to corrosion caused by polluted air. Benzotriazole is a



Treatment of bronze disease by the silver oxide method.



Cross-section (magnified × 15) of a fragment of Chinese Shang bronze, showing the original metal (centre). The copper chloride layer lies next to the metal. The reddish and orange layer is copper oxide (cuprite) and contains a few granules of redeposited copper. The outer green corrosion is the mineral malachite (basic copper carbonate).

strong complexing agent for copper. Impregnation of an ancient bronze exhibiting bronze disease with a 3 per cent solution of the agent will prevent the chloride from further attacking the copper. For two very good reasons benzotriazole is now preferred to most other methods of treating bronze disease: the treatment requires only a short period of time, and it produces no colour change in the bronze.

It has frequently been asked whether it is possible for recent bronzes to develop bronze disease. Unless the bronze has been buried (an excellent way of faking an old patina), the question might seem irrelevant. However, a recent bronze, by a still-living sculptor, was found to be sporting a light green powdery patch that was definitely bronze disease. Since bronzes of the last few hundred years have chemically-induced or applied lacquer patinas, it seems reasonable to assume that either hydrochloric acid was used in the pickling or that ammonium chloride was used to induce the desired patina. Certainly, in some way, conditions were favourable for the formation of cuprous chloride, or even for the direct formation of cupric chloride.

So cherish the patina on your ancient bronzes, and keep the bronzes dry. And take heart — the corrosion on your modern bronzes is most unlikely to be bronze disease.

Mrs. Carol J. Jack is a graduate of the University of Toronto, with a B.A. and an M.A. in chemistry. She joined the ROM *Conservation Department in 1965 and specializes in the conservation of archaeological metals.*

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